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INTEC Water Balance Report for Operable Unit 3-13, Group 4, Perched Water

November 2005

Idaho Cleanup Project

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INTEC Water Balance Report for Operable Unit 3-13, Group 4, Perched Water

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Prepared for the
U.S. Department of Energy
DOE Idaho Operations Office

ABSTRACT

This Idaho Nuclear Technology and Engineering Center (INTEC) Water Balance Report provides a 6-month water balance for INTEC. This INTEC water balance fulfills the data quality objective listed in the *Monitoring System and Installation Plan for Operable Unit 3-13, Group 4, Perched Water Well Installation* (DOE/ID-10774) to complete a water balance for INTEC water systems. This report serves as the follow-up report referenced in the *INTEC Water System Engineering Study* (DOE/ID-11115).

Findings in this report indicate that best estimates for INTEC of 1.1% known leaks and releases and 9.1% unaccounted water are consistent with industry standard values. Conclusions suggest that, although water balance values for INTEC are consistent with industry standards, the large volume of water used at INTEC still poses a potential risk to perched water contributions. To reduce the risk of water contributions to the perched water below INTEC, reducing facility water use, improving water system metering, and conducting regular water balances will aid in the reduction of possible perched water recharge derived from INTEC.

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ACRONYMS

AWMR	annual water monitoring report
DQO	data quality objective
ICDF	Idaho CERCLA Disposal Facility
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
MRDS	monitoring report/decision summary
PEW	process equipment waste
SRPA	Snake River Plain Aquifer
SWS	service waste system
WAG	waste area group
WSES	Water System Engineering Study

INTEC Water Balance Report for Operable Unit 3-13, Group 4, Perched Water

1. INTRODUCTION

Release sites within Waste Area Group (WAG) 3 were grouped according to shared characteristics or common contaminant sources in the *Final Record of Decision Idaho Nuclear Technology and Engineering Center, Operable Unit 3-13* (DOE-ID 1999). The seven groups identified in the Record of Decision were (1) Tank Farm Soils, (2) Soils Under Buildings and Structures, (3) Other Surface Soils, (4) Perched Water, (5) Snake River Plain Aquifer (SRPA), (6) Buried Gas Cylinders, and (7) SFE-20 Hot Waste Tank System. Group 4, Perched Water, consists of variably saturated groundwater zones above the regional SRPA. Figure 1-1 shows the location of the Idaho Nuclear Technology and Engineering Center (INTEC) within the Idaho National Laboratory (INL).

Currently, the perched water zones beneath INTEC result from recharge from precipitation infiltration, the Big Lost River, lawn irrigation, and other miscellaneous INTEC water sources (DOE-ID 1999). Perched water flow is primarily vertical and ultimately recharges the SRPA. Perched water has been contaminated by leaching and downward transport of contaminants from overlying surface soils and from two instances in which the INTEC injection well (CPP-23) collapsed and service wastewater was released to the perched zones.

Fluctuations in perched water levels beneath INTEC, observed during 2000–2004 when the Big Lost River did not flow, suggest that water leaks and discharges at INTEC may be contributing to the recharge of the perched water and downward transport of contaminants to the SRPA.

1.1 Background

An *INTEC Water System Engineering Study* (WSES) was conducted in 2003 (DOE-ID 2003). The scope of the study included a review of previous INTEC water balance studies, review of INTEC water use and discharge practices, development of an INTEC water balance, determination of operational releases, identification of data gaps associated with quantifying facility discharges, recommendations for improving water metering systems, and identification of planned infrastructure changes at INTEC that may affect facility discharges.

During the INTEC WSES, a defensible water balance for INTEC could not be developed because reliable water use data were lacking. The conclusion of the study provided recommendations to provide guidance on improving INTEC water balance capabilities and reporting and to decrease water discharges that could impact perched water zones beneath the facility.

1.2 Purpose

This INTEC Water Balance Report provides a water balance for INTEC for the time period of January 11, 2005, through July 11, 2005. This time period was selected because water metering for major inputs and outputs for INTEC was operational and considered adequate after January 10, 2005. The water balance was conducted for a 6-month time period as a means to accelerate the development of a baseline for improving water use efficiency at INTEC and to provide information for other programs, including Operable Unit 3-14, that could benefit from the information. The annual water monitoring report (AWMR) will include summary annual water balances in the future.

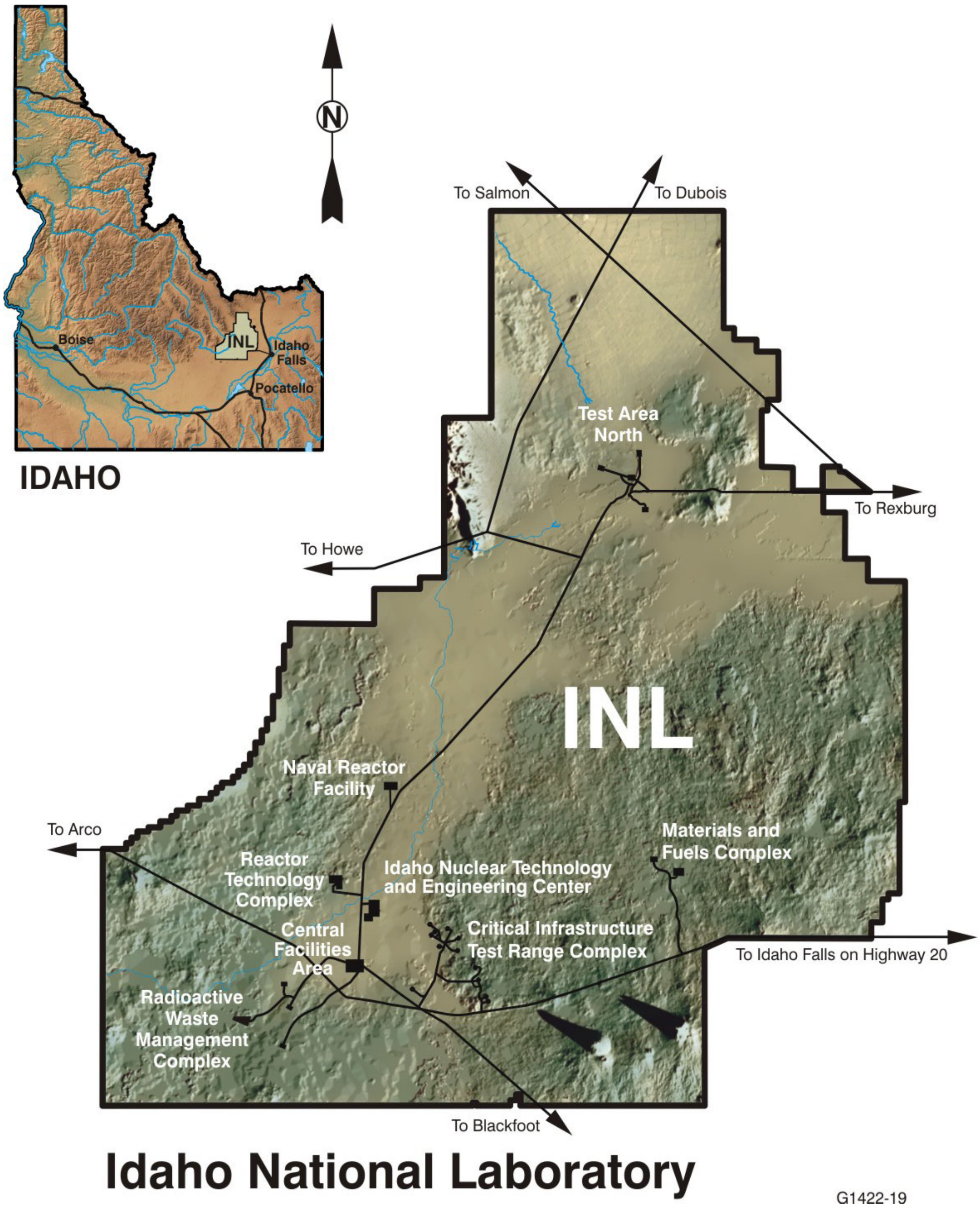

Figure 1-1. Location of the Idaho National Laboratory Site.

The INTEC water balance included in this report fulfills the data quality objective (DQO) listed in the *Monitoring System and Installation Plan for Operable Unit 3-13, Group 4, Perched Water Well Installation* (DOE-ID 2005) to complete a water balance for INTEC water systems. This report serves as the follow-up report referenced in the INTEC WSES (DOE-ID 2003). Information gathered from this water balance will support the development of the Group 4 monitoring report/decision summary (MRDS).

2. SUMMARY OF WSES RECOMMENDATIONS

Based on findings and data gaps discovered during the INTEC WSES, recommendations were developed to provide guidance on improving INTEC water balance capabilities and reporting and to decrease water discharges that could impact perched water zones beneath the facility. Table 2-1 lists the status of recommendations listed in the WSES.

Table 2-1. Actions taken and planned path forward for recommendations listed in the WSES.

WSES Recommendation	Action Being Implemented	Future Action	Action Eliminated	Discussion/Comments
Use/install data loggers on primary input and output systems of the plant. This includes utilizing data logging capabilities of flow totalizers as available.	X			Data logging capabilities for the raw water productions wells, fire water jockey pumps, and potable water system were installed and programmed and data were collected. In December 2004, Sewage Treatment Plant-treated effluent was rerouted from infiltration ditches to the Service Waste System (SWS). SWS flow is metered and data collected.
Install a flow meter on the outlet of the diesel-driven fire water pumps.			X	The use of the diesel-driven fire water pumps to supply water to the system was determined to be sporadic. For the purpose of an INTEC water balance, the amount of water used when the diesel-driven pumps are on will be estimated based on the amount of time the pumps run, as indicated by a zero reading on the fire water jockey pumps.
Log volumes OR install a flow meter in the line used to fill trucks at the inactive coal-fired steam generation plant.			X	When water trucks are filled at INTEC (not a frequent occurrence), fire water is typically used. The diesel fire water pumps are needed to do this. Thus, based on the response above, logging or metering of this water will be estimated based on the amount of time the diesel fire water pumps run, as indicated by a zero reading on the fire water jockey pumps.
Log volumes OR install a flow meter in the line used to fill the CPP-603 basins.			X	This recommendation will not be implemented because the basins will be emptied in the near future.
Install a flow meter on the boiler feed makeup line.	X			Installation of a new flow meter and data logger was completed for the boiler feed makeup line to provide a makeup rate to the steam system to aid in determining system losses.
Install flow meters to monitor the direct raw water used on lines 10” RW-NR-152863 and 8” RW-NR-152862.			X	This recommendation will not be implemented because the heat exchangers associated with the buildings (CPP-1604, -1605, and-1631) affecting the raw water flow of these lines are tentatively being assessed for replacement with electric units. The installation of meters on these lines would provide nominal benefit.

Table 2-1. (continued).

WSES Recommendation	Action Being Implemented	Future Action	Action Eliminated	Discussion/Comments
Install a new flow meter on the treated water system to replace the existing meter.		X		Currently treated water is monitored and metered. An upgrade to the treated water system is planned and includes a new metering system.
Create and maintain a monthly water balance log and tracking system.		X		An internal summary water balance will be updated and monitored quarterly and an annual water balance summary update will be reported in the AWMR.
Identify an individual who will serve as a central task lead for system accountability, maintenance, and data management and reporting.		X		This recommendation will be discussed with INTEC facility personnel for possible future implementation.
Control the discharge from the diesel-driven fire water pumps packing gland cooling.		X		This recommendation will be combined with a possible storm water system assessment and will be considered for implementation during development of the MRDS.
Control discharge from the diesel-driven fire water pumps engine cooling water.		X		This recommendation will be combined with a possible storm water system assessment and will be considered for implementation during development of the MRDS.
Control discharges during yearly fire hydrant testing.			X	This recommendation will not be implemented. Generally, discharges from fire hydrant testing are diffused or directed towards the tank farm drainage/run-off system, minimizing any influence on infiltration.
Reduce or eliminate maintained lawns.		X		This recommendation will be discussed with INTEC facility personnel for future implementation.
Include a system-wide leak check of the fire water system during the fire water system assessment that is conducted every 5 years.			X	Currently, fire water jockey pumps log minor fire system loads. Minor system problems can be detected when flows elevate above normal seasonal readings. If a leak is suspected, system isolations can aid in finding the leak. Catastrophic failures are obvious when the fire water pressure drops such that the diesel-driven water pumps turn on.

3. INTEC WATER BALANCE

To develop a facility water balance for INTEC, sources of water input and output for the facility needed to be identified. For the purpose of this water balance, Figure 3-1 illustrates a schematic representation of INTEC water system inputs and outputs. This water balance uses data collected during a 6-month timeframe spanning from January 11, 2005, through July 11, 2005. The following sections provide explanations for inputs, outputs, assumptions, and a system water balance for INTEC.

3.1 Input Descriptions

Two main sources exist that provide input for water systems at INTEC. These sources are raw water wells and potable water wells. Following are descriptions of each input for the INTEC water system.

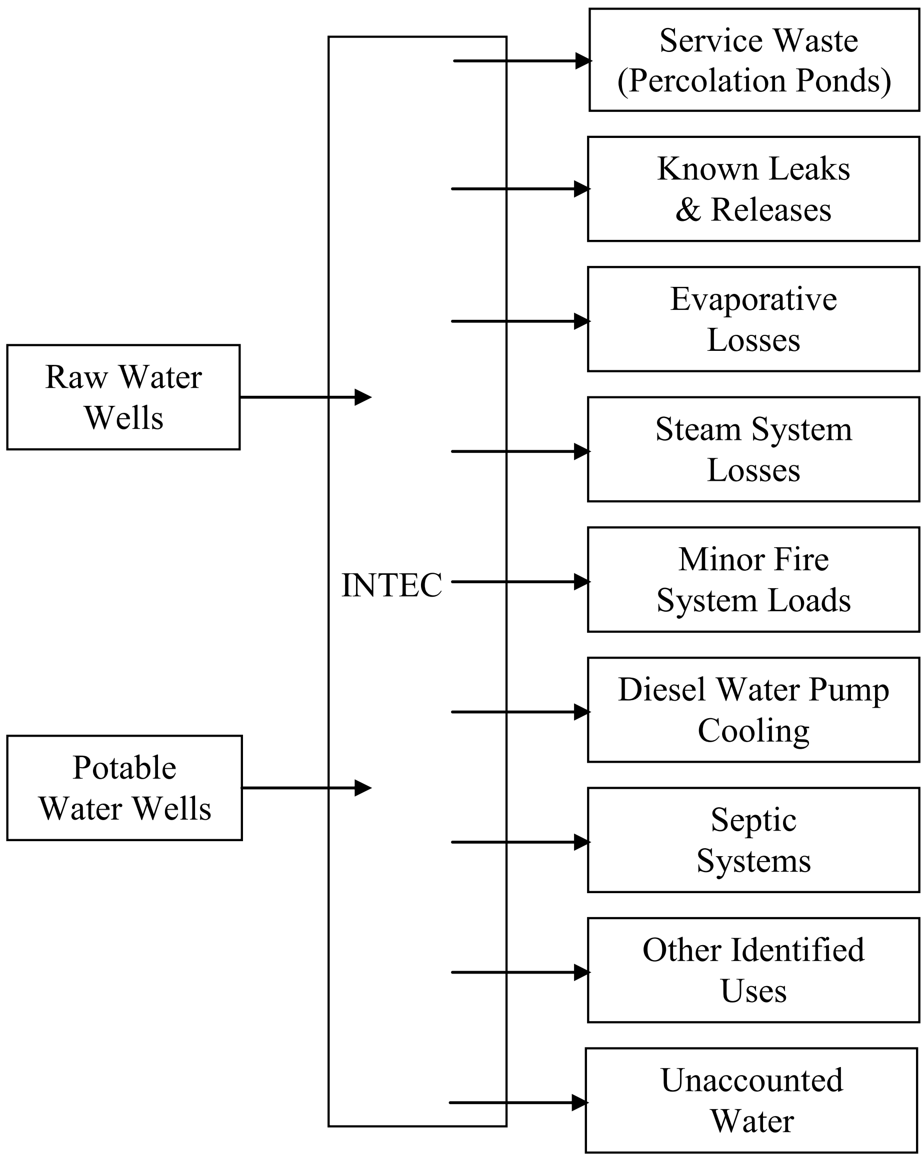

Figure 3-1. Schematic representation of water system inputs and outputs for INTEC.

3.1.1 Raw Water Wells

Two raw water production wells, located inside the northwestern portion of INTEC, supply the facility with raw water from the SRPA. During normal operation, one of the two deep well raw water pumps is active and the second is on standby/backup (CPP-01 and CPP-02). Pumping typically alternates monthly between the two wells. Approximately 1.0–1.5 million gpd of groundwater are typically pumped from the raw water wells. Raw water is pumped into two fire water storage tanks and overflows through internal standpipes into two raw water storage tanks, ensuring adequate fire water remains in storage at all times. Water level controls within the raw water storage tanks control raw water pumping, shutting off the pump when the operational tank capacity is reached. Raw water is supplied to INTEC to support operations and provide water for several water systems within the facility, including the treated water system and demineralized water system.

3.1.2 Potable Water Wells

Potable water is supplied from the SRPA by two potable water wells located approximately 600 ft north of the INTEC security fence (CPP-04 and CPP-05). Approximately 20,000–25,000 gpd of groundwater are typically pumped from the potable water wells. Potable water is pumped to two storage tanks within the INTEC fence, from which it is chlorinated and distributed throughout the facility for water uses, including human consumption.

3.2 Output Descriptions

As depicted in Figure 3-1, nine identified output pathway groups are quantified in this water balance. The overwhelming majority of output from water systems in INTEC exits through the SWS to the percolation ponds, located approximately 2 miles southwest of INTEC. The other groups quantified in this water balance are either discharges to the environment and/or to storm water drains and ditches within the facility or are unaccounted outputs. No storm water is assumed to find its way into the SWS. The following sections identify and describe each output pathway group.

3.2.1 Service Waste (Percolation Ponds)

The SWS collects wastewater, primarily comprising noncontact cooling water, steam condensates, processed sanitary wastewater, reverse osmosis discharge, water softener discharge, boiler blowdown wastewater, and other nonhazardous liquids. Service wastewater is gravity-fed to CPP-797/1749 where it is monitored, sampled, and ultimately pumped through two discharge lines to the new percolation ponds located approximately 2 miles southwest of INTEC. The SWS collects liquid wastewater from all internal water systems at INTEC (excluding contaminated liquid wastewater) and is the primary exit path of wastewater from INTEC water systems.

3.2.2 Known Leaks and Releases

This output includes identified water system leaks and abnormal discharges for the time period specified for this water balance. These leaks and releases include identified water system leaks and abnormal operational discharges that do not make their way to the SWS.

3.2.3 Evaporative Losses

For the purpose of this water balance, evaporative losses are assumed to occur primarily in three locations. These locations are CPP-603 basins, CPP-666 basins, and the sewage treatment lagoons. The basins are maintained for the storage of materials within Buildings CPP-603 and CPP-666. These basins are periodically recharged with water to maintain their water levels within the operational range. Basin recharge is conducted to compensate for natural evaporative losses from these basins, which are not metered. Because CPP-666 basins are equipped with a leak detection system and because water losses from CPP-603 basins are consistent with evaporative rates (EDF-2405), recharge to the basins during the time period of this balance is considered to be equal to the evaporative water loss that affects the water balance.

Two of the four sewage treatment lagoons aerate sanitary wastewater derived from INTEC prior to it being directed to the SWS. Although aeration increases the rate of evaporation, evaporative losses for all four ponds are assumed to be consistent with normal evaporation rates for the area.

3.2.4 Steam System Losses

This output includes condensate discharges and releases of steam to the atmosphere or ground. For the purpose of this water balance, losses from the steam system are assumed to include operational losses (e.g., steam releases to atmosphere, blowdown) as well as any leaks or releases from the system during the timeframe of this water balance.

3.2.5 Minor Fire Water System Loads

This output includes only fire water system loads that are not directed to monitored outputs. For the purpose of this water balance, the quantification of this output includes minor fire water system loads consisting of minor operational uses, CPP-652 lawn irrigation, heat pumps, and fire water testing.

3.2.6 Diesel Water Pump Cooling

The fire water and raw water systems are infrequently used. Each has diesel water pumps that are regularly tested to maintain proper functionality and are used when system loads exceed normal supply demands. When these diesel pumps are turned on, they use a single-pass water cooling system which is discharged to unlined storm ditches. Also, leak-off from packing glands of one of the diesel-driven fire water pumps consistently discharges a minor amount of water to an unlined storm water ditch.

This output includes cooling water discharges from the diesel-driven water pumps, as well as the small gland leak-off from one of the fire water pumps.

3.2.7 Septic Systems

While a large majority of buildings at INTEC discharge sewage to the sanitary waste system, some buildings use septic systems. Discharges to these septic systems are quantified in this water balance as an output from the INTEC water systems.

3.2.8 Other Identified Uses

This output includes other identified water uses not covered in previous output descriptions for this water balance. This output includes wastewater sent to the Process Equipment Waste (PEW) Evaporator, Idaho CERCLA Disposal Facility (ICDF) water uses not ultimately plumbed to the SWS, evaporative coolers, and remaining lawn irrigation (does not include CPP-652 lawn). Water usages for this output are not returned to INTEC wastewater systems for quantification and are considered an output from INTEC water systems for this water balance.

3.2.9 Unaccounted Water

This output is derived from the difference between identified inputs and other outputs identified previously. This output accounts for any water not identified as an output for this water balance. Unaccounted water could include unidentified discharges, leaks, evaporative losses, or other unidentified nonmetered outputs.

3.3 Water Balance Data Compilation

To develop a water balance for INTEC, data values for each input and output were quantified. Inputs and outputs were identified and quantified through data collection, observation, subject matter expert input, and reference documents and materials. This water balance includes data for the time period of January 11, 2005, through July 11, 2005. Tables 3-1 and 3-2 provide values for each input and output. Figure 3-2 graphically shows inputs and outputs. Appendixes A–J provide descriptions of how data were collected/calculated, assumptions that were made, and how interval estimates were associated with data values. Appendix K contains detailed drawings of the INTEC water systems from which the water balance data were collected.

Table 3-1. INTEC water balance input compilation data for January 11, 2005, through July 11, 2005.

Inputs	Total (gal)	Interval Estimate
Raw water wells (CPP-01 and CPP-02)	228,466,000	(226,409,806–230,522,194)[a]
Potable water wells (CPP-04 and CPP-05)	5,192,995	(5,135,872–5,250,118)[a]
Total	233,658,995	(231,643,147–235,674,843)[b]

a. Interval estimate is a range of values from expert elicitation.
b. Interval estimate is a 95% probability interval.

Table 3-2. INTEC water balance output compilation data January 11, 2005, through July 11, 2005.

Outputs (not including unaccounted water)	Total (gal)	Interval Estimate
Service waste (percolation ponds)	207,419,800	(205,553,021–209,286,579)[a]
Known leaks and releases	2,515,330	(2,253,270–2,777,390)[b]
Brine water leak near CPP-1610	9,522	(2,918–16,126)[b]
Potable water leak near CPP-1673	996,983	(996,158–997,808)[c]
Fire Hydrant 1505 leak (S.E. side of CPP-603)	1,493,856	(1,231,880–1,755,832)[c]
Fire Hydrant 6511 leak (S. side of CPP-699)	14,969	(14,774–15,163)[c]
Evaporative losses	505,604	(478,920–532,288)[b]
CPP-603 basins	76,300	—[d]
CPP-666 basins	94,836	—[d]
Sewage treatment lagoons	334,468	(307,784–361,152)[b]

Table 3-2. (continued).

Outputs (not including unaccounted water)	Total (gal)	Interval Estimate
Steam system losses (steam leak near CPP-1608 and condensate leak near CPP-666)	699,240	(523,850–874,630)[a]
Minor fire water system loads	236,789	(185,595–287,983)[b]
CPP-603 basin work	15,895	(12,780–19,010)[b]
Fire hydrant testing	46,750	(23,312–70,188)[b]
CPP-652 lawn irrigation	173,748	(128,342–219,154)[b]
CPP-697 heat pump	396	(84–708)[b]
Diesel water pump cooling	206,047	(148,373–263,721)[b]
Fire water pumps (CPP-1642 and CPP-1643)	156,800	(99,150–214,450)[b]
Fire water pump gland leak-off (CPP-1643)	41,147	(40,622–41,670)[c]
Raw water pump	8,100	(6,510–9,690)[b]
Septic systems	85,725	(54,430–117,020)[b]
CPP-656	60,375	(30,928–89,822)[b]
CPP-655	10,710	(2,117–19,303)[b]
CPP-626	14,640	(8,442–20,838)[b]
Other identified uses	648,625	(543,985–753,265)[b]
PEW Evaporator uses	221,270	—[d, e]
ICDF uses	3,200	—[d]
Evaporative cooler uses	126,853	(29,294–224,412)[b]
Other lawn irrigation	297,302	(259,463–335,140)[b]
Total	212,317,160	(210,419,033–214,215,287)[b]

a. Interval estimate is a range of values from expert elicitation.
b. Interval estimate is a 95% probability interval.
c. Interval estimate is a 95% confidence interval for the total.
d. The assumed value is considered valid with no applied probability interval (assumed negligible).
e. All transfers to the PEW Evaporator are assumed to affect the water balance. Precipitation infiltration transfers from tank vaults are considered insignificant for the purpose of this water balance.

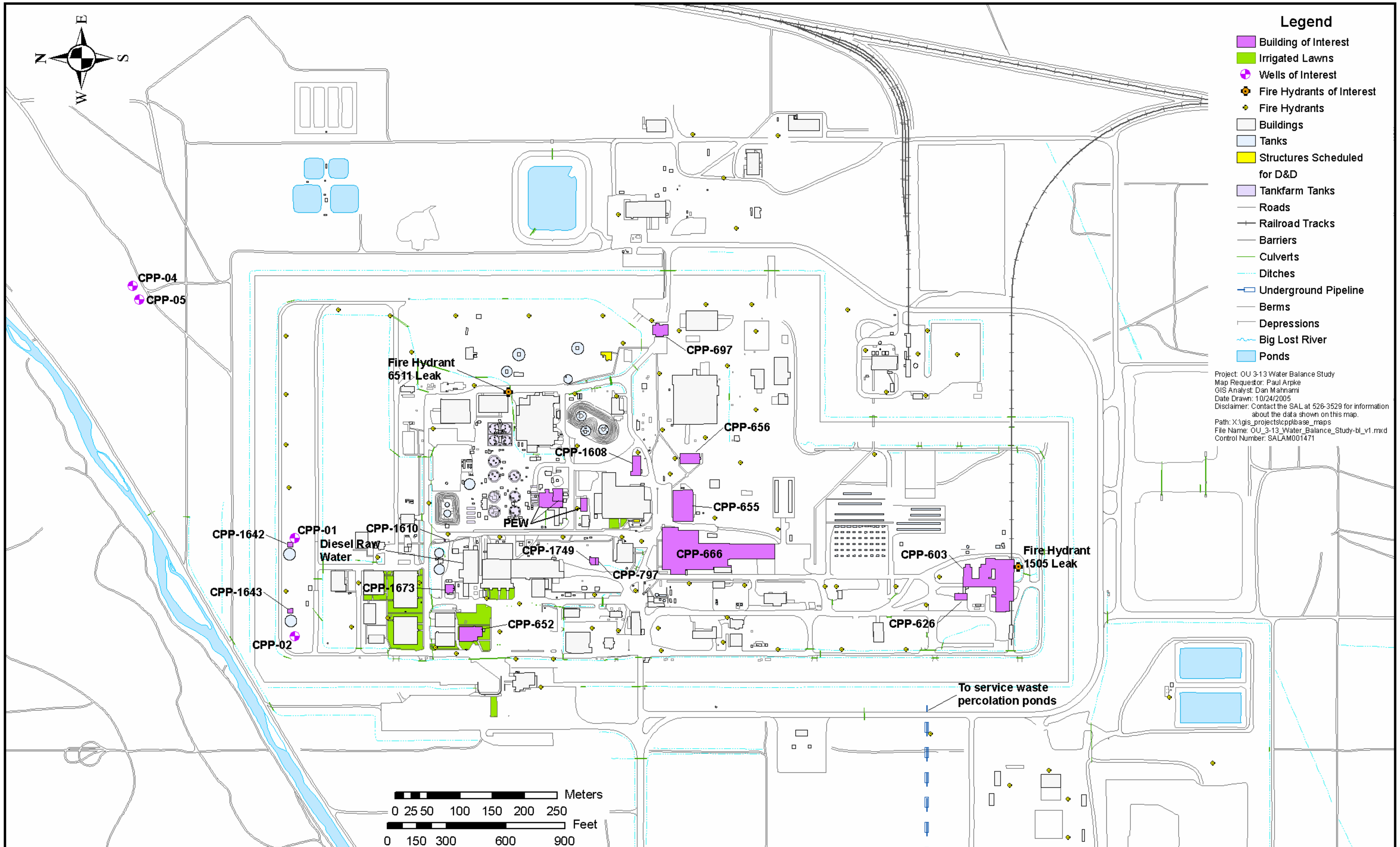

Figure 3-2. Location of various water balance inputs and outputs at INTEC.

3.3.1 Methods for Interval Estimates

Uncertainty in the water balance was incorporated from uncertainties in the components. The uncertainties were presented as interval estimates: ranges, probability intervals, and confidence intervals. For values determined from expert elicitation, a range of values was presented. For calculated values with at least some values determined from expert elicitation, a probability interval was presented. For observed data, confidence intervals for the total or mean were presented.

A 95% probability interval is the range within which 95% of the values are expected to fall, making a loose assumption of normality. The assumption is loose, in that probability level (95%) is approximately correct if the data are not normal, but the values are expected to be symmetric. The 95% probability interval was calculated as $x \pm 1.96 \times s$, where *x* was the estimated value and *s* was the estimated standard deviation. The probability interval was used when observed data were not available, or it was combined with observed data.

A two-sided 95% confidence interval (henceforth referred to as the confidence interval) for the mean is the range of values within which the true mean is expected to be 95% of the time. The confidence interval was calculated as $x \pm t_{0.975,n-1} \times s/\sqrt{n}$, where the *t* was the 97.5th percentile of the *t* distribution with *n-1* degrees of freedom. The confidence level for this interval was based on the assumption of normality. It is assumed the data were at least symmetric, which provided approximately the stated confidence level. The confidence interval was used when observed data were available.

The standard deviation from expert elicitation was estimated as 1/4 of the range of values. This estimate was based on the assumption of approximate normality (at least symmetry) and 95% of the data values being between plus or minus approximately 2 standard deviations. To provide a conservative result, this method was used rather than assuming the range represents 99% (i.e., the estimate of standard deviation would be 1/6 range).

For values that were calculated, the delta method was used to estimate the variance. The delta method, generally, is the name given the process of deriving the distribution of a function of random variables. Part of this method was used to estimate the variance of a function of random variables. The estimate for the variance of a function, g, of two independent random variables *x* and *y*, is obtained by the equation below.

$$\hat{\mathrm{v}}\mathrm{ar}(g(x,y)) = \left(\left. \frac{\partial g(\underline{\mu})}{\partial \mu_x} \right|_{\underline{\mu}=\binom{x}{y}} \right)^2 \mathrm{var}(x) + \left(\left. \frac{\partial g(\underline{\mu})}{\partial \mu_y} \right|_{\underline{\mu}=\binom{x}{y}} \right)^2 \mathrm{var}(y)$$

where $\underline{\mu} = \begin{pmatrix} \mu_x \\ \mu_y \end{pmatrix}$, the unknown true mean for *x* and *y*, $\left(\partial g(\underline{\mu})/\partial \mu_x\right)$ is the partial derivative of *g* with respect to μ_x, the horizontal line and subscript following the partial derivative indicates that the result of the derivation is evaluated at the generic estimates, x and y, and the sample variances are used to estimate the variance terms for *x* and *y*. Most of the applications of the delta method in this report are not based on data, but on expert judgment, so the random variable and the estimate are considered one in the same. For $g = x \times y$, the estimated variance was $\hat{\mathrm{v}}\mathrm{ar}(g) = y^2\ \mathrm{var}(x) + x^2\ \mathrm{var}(y)$. For $g = x / y$, the estimated variance was $\hat{\mathrm{v}}\mathrm{ar}(g) = (1/y)^2\ \mathrm{var}(x) + (x/y^2)^2\ \mathrm{var}(y)$. This was used for the Percentage of Input estimates.

For summations of independent random variables, the variance of the sum is the sum of the variances. This relationship is not true for the standard deviations, which is why interval estimate limits were not simply summed. Throughout the report, independence is assumed for variables within functions for which the delta method is used to estimate the variance. This may generally be the case, but a covariance term cannot readily be determined. The resulting estimate of variance is larger (conservative) using the assumption of independence.

3.3.2 Water Balance Data Summaries

Table 3-3 includes a summary of the data and the overall unaccounted water output for INTEC for the time period of this water balance.

To show where INTEC water outputs are directed, Table 3-4 lists the general discharge locations of the outputs for this water balance. Discharges to ground and to unlined ditches have a potential impact to perched water recharge from the facility. Table 3-5 identifies potential contributors to the perched water beneath INTEC.

Table 3-3. Summary of INTEC water balance values for January 11, 2005, through July 11, 2005.

	Total (gal)	95% Probability Interval	Percentage of Input (95% Probability Interval)
Identified inputs	233,658,995	(231,643,147–235,674,843)	100%
Identified outputs	212,317,160	(210,419,033–214,215,287)	90.9% (89.7–92.0)
Unaccounted outputs	21,341,835	(18,572,985–24,110,685)	9.1% (7.9–10.3)

Table 3-4. INTEC water balance output discharge locations.

Outputs		Discharge Location	% of Input (Best Estimate)
Service waste (percolation ponds)		Percolation ponds	88.8 %
Known leaks and releases	Brine water leak	Ground inside INTEC	1.1%
	Potable water leak	Ground inside INTEC	
	Fire Hydrant 1505 leak	Ground inside INTEC	
	Fire Hydrant 6511 leak	Lined ditch inside INTEC	
Evaporative losses	CPP-603 basins	Atmosphere	0.2%
	CPP-666 basins	Atmosphere	
	Sewage treatment lagoons	Atmosphere	
Steam system losses		Ground inside INTEC/atmosphere	0.3%
Minor fire water system loads	CPP-603 basin work	CPP-603 basins	0.1%
	Fire hydrant testing	Ground inside INTEC	
	Lawn irrigation	Ground inside INTEC	
	CPP-697 heat pump	Ground inside INTEC	

Table 3-4. (continued).

Outputs		Discharge Location	% of Input (Best Estimate)
Service waste (percolation ponds)		Percolation ponds	88.8 %
Diesel water pump cooling	Fire water pumps	Unlined ditch inside INTEC	0.1%
	Fire water pump gland leak-off	Unlined ditch inside INTEC	
	Raw water pump	Unlined ditch inside INTEC (leads to lined ditch)	
Septic systems	CPP-656	Ground inside INTEC	<0.1%
	CPP-655	Ground inside INTEC	
	CPP-626	Ground inside INTEC	
Other identified uses	PEW Evaporator uses	Atmosphere/tank farm	0.3%
	ICDF uses	Ground outside INTEC	
	Evaporative cooler uses	Atmosphere	
	Other lawn watering	Ground inside INTEC	
Unaccounted water output		Unknown	9.1%

Table 3-5. INTEC outputs with potential to affect perched water beneath the facility.

Outputs	Discharge Location	Best Estimate Volume (gal)	Best Estimate % of Input
Brine water leak	Ground inside INTEC	9,522	4.1E-03%
Potable water leak	Ground inside INTEC	996,983	4.3E-01%
Fire Hydrant 1505 leak	Ground inside INTEC	1,493,856	6.4E-01%
Steam system losses	Ground inside INTEC/atmosphere	699,240[a]	3.0E-01%
Fire hydrant testing	Ground inside INTEC	46,750	2.0E-02%
Total lawn irrigation	Ground inside INTEC	471,050	2.0E-01%
CPP-697 heat pump	Ground inside INTEC	396	1.7E-04%
Fire water pumps cooling water	Unlined ditch inside INTEC	156,800	6.7E-02%
Fire water pump gland leak-off	Unlined ditch inside INTEC	41,147	1.8E-02%
Raw water pump cooling water	Unlined ditch inside INTEC (leads to lined ditch)	8,100	3.5E-03%

Table 3-5. (continued).

Outputs	Discharge Location	Best Estimate Volume (gal)	Best Estimate % of Input
CPP-656 septic system	Ground inside INTEC	60,375	2.6E-02%
CPP-655 septic system	Ground inside INTEC	10,710	4.6E-03%
CPP-626 septic system	Ground inside INTEC	14,640	6.3E-03%
Unaccounted water output	Unknown	21,692,233a	9.1E+00%
	Total	25,701,802	11.0E+00%

a. The portion of this value that could affect the perched water is unknown.

4. CONCLUSIONS AND CONSIDERATIONS

Based on the results of this INTEC water balance for January 11, 2005, through July 11, 2005, water system accountability at INTEC is consistent with industry standards. Although water use functions at INTEC are unique to the facility, the percentages of unaccounted water and water leaks are comparable to a typical industrial/manufacturing facility. Typical water balance values for manufacturers, including metal fabricators, rubber products, aeronautical, and cardboard product manufacturers, indicate approximately 3% loss from leaks and 9% unaccounted water (North Carolina Department of Environment and Natural Resources 2000). These values are consistent with the best-estimate results for INTEC of 1.1% known leaks and releases and 9.1% unaccounted water.

Although the percentage of the best-estimate findings are consistent with industry standards, the potential volume of water that could impact Group 4, Perched Water, beneath INTEC is significant and substantial. The outputs that could affect perched water beneath INTEC are identified in Table 3-5. Unaccounted water is conservatively included as a contributor because it could include leaks and unidentified discharges to ground. Contributors to overall perched water recharge beneath INTEC include anthropogenic sources, precipitation, and the Big Lost River. For overall perched water recharge beneath INTEC, it is conservatively assumed that anthropogenic sources and precipitation each contribute approximately 15% and the Big Lost River contributes about 70%.

Some general considerations to reduce perched water recharge from anthropogenic sources at INTEC are listed below. The MRDS will take these considerations into account if it is determined that Phase II remediation is necessary for Group 4.

Reduce Water Use

Large volumes of water are used daily at INTEC. The more water that is used within the INTEC facility, the higher the potential for recharge of the perched water beneath the facility. Reducing the amount of water used at INTEC would help reduce recharge of the perched zones. A reduction in water use would also aid in pinpointing some leaks because excess flow due to leaks would be more recognizable when overall normal system flows are decreased.

Timely isolation and/or repair of leaks will also reduce the amount of water used within INTEC and minimize the impact they may have on perched water levels.

Improve Water System Metering

Currently, adequate metering is in place for raw water production wells, potable water use, SWS outputs, and various other water uses to produce an overall INTEC water balance.

Improving metering on individual water systems within INTEC (e.g., treated water system) will provide for better water accountability within the facility. Improved metering will also aid in the identification of potential areas requiring repair by indicating possible system losses.

Conduct Regular Water Balances

Conducting regular water balances will aid in determining the amount of anthropogenic water from INTEC that possibly contributes to perched water below the facility. It is also a way to monitor for unidentified leaks and determine if action is needed to find a potential leak. Tracking water use within the facility is also a good management practice. Annual summary water balances will be included in future AWMRs until they are determined to no longer be necessary.

Reducing water use, improving water system metering, and conducting regular facility water balances will aid in minimizing losses to ground and will help remedy problem areas as they are identified.

5. REFERENCES

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DOE-ID, 2005, *Monitoring System and Installation Plan for Operable Unit 3-13, Group 4, Perched Water Well Installation*, DOE/ID-10774, Rev. 3, U.S. Department of Energy Idaho Operations Office, January 2005.

EDF-2405, 2002, "CPP-603 Basin Water Level Review," Rev. 0, Idaho National Engineering and Environmental Laboratory, September 2002.

North Carolina Department of Environment and Natural Resources, *Water Efficiency, Sound Principles of Water Management*, http://www.p2pays.org/ref/04/03098.pdf, Web page updated June 6, 2000, Web page visited August 4, 2005.

Appendix A

Raw Water Well Data

Appendix A

Raw Water Well Data

Water pumped from the raw water wells is metered near the well heads using clamp-on ultrasonic flow meters, and data are recorded using instrument data logging capabilities. Totalized flow values, flow rates, date, and time are recorded approximately every 5 minutes. Data are downloaded from these instruments monthly and stored for later use. The total amount of water pumped from the raw water wells for the timeframe of this water balance is presented in Table A-1.

The flow meters have a reported accuracy of ± 0.5–1% and repeatability of ± 0.15%. A range of values is determined by summing these uncertainties as a percent of the total. The accuracy, assuming the midpoint of 0.75%, is ± 1,713,495 gal and the repeatability is ± 342,699 gal. The range is determined as 228,466,000 ± (1,713,495 + 342,699) Thus, the range for total water pumped from raw water wells at INTEC from January 11, 2005, through July 11, 2005, is 226,409,806 to 230,522,194 gal.

Table A-1. Total gallons of water pumped from raw water wells at INTEC from January 11, 2005, through July 11, 2005.

Date	Jan 05	Feb 05	Mar 05	Apr 05	May 05	Jun 05	Jul 05
1	NA[a]	1,389,000	1,534,000	1,167,000	736,000	1,560,000	1,332,000
2	NA	1,119,000	1,157,000	1,334,000	1,469,000	1,254,000	1,327,000
3	NA	1,205,000	1,168,000	1,360,000	1,366,000	906,000	1,260,000
4	NA	1,250,000	1,530,000	1,190,000	819,000	1,238,000	729,000
5	NA	1,387,000	1,533,000	1,075,000	1,457,000	1,361,000	1,331,000
6	NA	1,416,000	1,563,000	1,097,000	1,100,000	1,360,000	1,329,000
7	NA	1,429,000	1,409,000	1,227,000	1,206,000	1,352,000	1,282,000
8	NA	1,383,000	1,231,000	1,323,000	1,452,000	1,030,000	1,299,000
9	NA	1,394,000	1,293,000	1,341,000	878,000	1,012,000	1,276,000
10	NA	1,167,000	1,565,000	1,346,000	1,335,000	1,314,000	1,184,000
11	1,461,000	1,223,000	1,550,000	1,115,000	1,462,000	1,322,000	1,329,000
12	1,312,000	1,021,000	1,494,000	929,000	1,141,000	1,331,000	NA
13	953,000	1,340,000	975,000	1,286,000	1,082,000	1,022,000	NA
14	1,481,000	1,348,000	1,269,000	1,337,000	1,477,000	1,022,000	NA
15	1,488,000	1,403,000	1,487,000	1,313,000	1,124,000	1,176,000	NA
16	1,483,000	1,382,000	1,237,000	1,325,000	1,057,000	1,332,000	NA
17	931,000	1,281,000	1,492,000	1,238,000	1,490,000	1,377,000	NA
18	1,305,000	1,312,000	1,105,000	937,000	1,410,000	1,370,000	NA
19	1,517,000	1,262,000	1,126,000	1,192,000	836,000	1,373,000	NA
20	1,485,000	1,251,000	1,487,000	1,339,000	1,456,000	1,323,000	NA

Table A-1. (continued).

Date	Jan 05	Feb 05	Mar 05	Apr 05	May 05	Jun 05	Jul 05
21	1,199,000	1,252,000	1,394,000	1,313,000	1,176,000	875,000	NA
22	1,019,000	1,283,000	798,000	1,000,000	1,047,000	1,343,000	NA
23	1,479,000	1,626,000	1,467,000	898,000	1,471,000	1,386,000	NA
24	1,496,000	1,387,000	1,409,000	1,313,000	786,000	1,200,000	NA
25	1,071,000	1,396,000	894,000	1,314,000	1,360,000	919,000	NA
26	1,236,000	1,383,000	1,312,000	693,000	735,000	1,268,000	NA
27	1,469,000	1,405,000	1,494,000	1,266,000	1,385,000	1,384,000	NA
28	1,466,000	1,336,000	1,129,000	1,287,000	707,000	1,325,000	NA
29	1,177,000	No data	1,045,000	1,288,000	1,415,000	1,139,000	NA
30	1,037,000	No data	1,444,000	1,428,000	1,329,000	849,000	NA
31	1,485,000	No data	966,000	No data	893,000	No data	NA
Total	27,550,000	37,030,000	40,557,000	36,271,000	36,657,000	36,723,000	13,678,000
Total	228,466,000						

a. NA = not applicable.

Appendix B

Potable Water Well Data

Appendix B

Potable Water Well Data

Water pumped from the potable water wells is metered using a clamp-on ultrasonic flow meter, and data are recorded using instrument data logging capabilities. The total potable water used is metered inside the INTEC facility prior to distributing it for use. Totalized flow values, flow rates, date, and time are recorded approximately every 6 minutes. Data are downloaded from these instruments monthly and stored for later use. The total amount of potable water distributed and used for the timeframe of this water balance is presented in Table B-1.

The flow meters have a reported accuracy of ± 1% and repeatability of ± 0.1%. A range of values for flow is determined by summing these uncertainties with respect to the total. The accuracy is ± 51,930 gal and the repeatability is ± 5,193 gal. The range is calculated as 5,192,995 ± (51,930 + 5,193). Thus, the range for total water pumped from potable water wells at INTEC from January 11, 2005, through July 11, 2005, is 5,135,872 to 5,250,118 gal.

Table B-1. Total gallons of potable water used at INTEC from January 11, 2005, through July 11, 2005.

Date	Jan 05	Feb 05	Mar 05	Apr 05	May 05	Jun 05	Jul 05
1	NA[a]	32,047	37,069	112,405	11,555	24,107	4,326
2	NA	36,494	34,875	104,789	27,663	24,099	5,755
3	NA	31,176	34,040	100,503	29,694	7,060	7,052
4	NA	16,526	13,523	122,379	27,991	6,425	6,758
5	NA	13,991	11,171	131,472	30,451	8,175	28,516
6	NA	14,488	8,942	129,588	11,321	25,758	37,699
7	NA	32,997	29,151	136,044	12,760	26,405	30,606
8	NA	44,776	31,636	120,841	11,815	26,207	6,908
9	NA	40,937	28,230	70,905	29,830	27,547	11,575
10	NA	31,871	30,695	13,455	30,220	8,138	13,519
11	34,522	14,894	14,555	33,145	31,490	7,996	23,681
12	35,308	10,820	12,748	31,615	31,832	8,266	NA
13	34,955	11,183	12,298	35,028	11,927	27,425	NA
14	17,224	29,541	31,025	38,990	13,014	29,882	NA
15	16,462	31,151	33,742	11,198	13,503	28,153	NA
16	11,934	30,806	44,507	8,312	32,357	33,158	NA
17	29,249	33,009	35,489	10,271	32,649	8,683	NA
18	35,347	16,669	13,191	32,755	30,098	8,249	NA
19	33,915	14,627	11,436	35,458	25,373	7,861	NA
20	31,233	12,523	12,877	32,457	14,761	26,256	NA
21	12,807	30,491	30,760	30,416	10,770	24,156	NA
22	11,184	34,009	33,378	14,073	12,480	24,472	NA

Table B-1. (continued).

Date	Jan 05	Feb 05	Mar 05	Apr 05	May 05	Jun 05	Jul 05
23	15,604	32,980	33,766	11,529	27,796	25,255	NA
24	34,625	34,042	34,547	12,309	30,128	4,211	NA
25	36,702	20,285	31,007	28,717	29,193	3,882	NA
26	38,193	15,424	28,094	29,551	25,017	4,496	NA
27	34,006	16,745	26,813	31,254	10,951	29,307	NA
28	15,049	34,201	52,917	35,539	10,508	38,405	NA
29	13,175	No data	50,482	14,433	10,869	37,945	NA
30	13,193	No data	63,789	12,284	10,692	20,606	NA
31	30,857	No data	118,361	No data	24,231	No data	NA
Total	535,544	718,703	985,114	1,531,715	662,939	582,585	176,395
Total	5,192,995						

a. NA = not applicable.

Appendix C

Service Waste Discharge Data

Appendix C

Service Waste Discharge Data

SWS discharges that are sent to the percolation ponds are metered and data are recorded and monitored. Data are recorded from these flow meters and daily flow values are assessed. The total amount of wastewater from the SWS that was recorded as going to the percolation ponds during the time period of this water balance is presented in Table C-1.

The flow meters have an assumed accuracy of ± 0.5%–1% and repeatability of ± 0.15%. These values were obtained from specifications on similar instruments. A range of values for flow is determined by summing these uncertainties with respect to the total. The accuracy, assuming the midpoint of 0.75%, is ± 1,555,649 gal and the repeatability is ± 311,130 gal. The range is calculated as 207,419,800 ± (1,555,649 + 311,130). Thus, the range for total water sent to the percolation ponds from January 11, 2005, through July 11, 2005, is 205,553,021 to 209,286,579 gal.

Table C-1. Total gallons of water sent to the percolation ponds from INTEC from January 11, 2005, through July 11, 2005.

Date	Jan 05	Feb 05	Mar 05	Apr 05	May 05	Jun 05	Jul 05
1	NA[a]	1,146,500	1,250,000	1,109,000	1,121,100	1,152,800	1,037,600
2	NA	1,159,300	1,350,000	1,118,700	1,105,800	1,167,600	1,037,300
3	NA	1,196,100	1,316,600	1,026,700	1,105,000	1,108,600	1,006,000
4	NA	1,184,100	1,288,800	1,080,800	1,146,300	1,081,100	1,011,400
5	NA	1,151,900	1,299,000	1,131,300	1,104,000	1,114,000	1,017,100
6	NA	1,167,000	1,312,600	1,115,000	1,136,700	1,156,500	1,027,000
7	NA	1,193,300	1,284,100	1,112,100	1,108,800	1,156,100	1,028,200
8	NA	1,166,400	1,336,300	1,111,500	1,082,100	1,054,800	1,095,500
9	NA	1,153,300	1,375,600	1,117,700	1,096,800	1,130,900	1,189,300
10	NA	1,176,800	1,359,800	1,097,000	1,197,000	1,133,000	1,176,900
11	1,169,300	1,176,000	1,368,300	1,091,800	1,230,400	1,094,400	1,159,800
12	1,091,200	1,122,100	1,243,600	1,068,700	1,139,100	1,028,600	NA
13	1,204,100	1,046,100	1,180,200	1,107,300	1,215,600	1,076,200	NA
14	1,218,900	1,052,600	1,176,900	1,086,400	1,140,800	1,101,300	NA
15	1,186,900	1,129,700	1,185,700	1,104,200	1,140,500	1,087,300	NA
16	1,205,100	1,223,200	1,183,800	1,101,300	1,135,900	1,102,400	NA
17	1,141,800	1,208,100	1,197,800	1,109,900	1,150,400	1,137,600	NA
18	1,215,400	1,242,600	1,179,800	1,094,300	1,215,500	1,149,800	NA
19	1,264,100	1,230,400	1,196,900	1,131,800	1,216,100	1,145,400	NA
20	1,196,600	1,196,400	1,160,900	1,123,900	1,123,300	1,073,800	NA

Table C-1. (continued).

Date	Jan 05	Feb 05	Mar 05	Apr 05	May 05	Jun 05	Jul 05
21	1,170,200	1,201,900	1,133,200	1,076,500	1,106,600	1,088,500	NA
22	1,144,800	1,238,300	1,157,200	1,029,500	1,146,000	1,071,300	NA
23	1,123,900	1,251,900	1,160,200	1,011,200	1,163,900	1,135,700	NA
24	1,148,100	1,230,200	1,152,800	1,011,500	1,033,100	1,093,200	NA
25	1,186,200	1,228,000	1,168,400	989,300	1,011,800	1,070,100	NA
26	1,224,800	1,212,400	1,170,400	1,024,400	938,100	1,090,800	NA
27	1,298,300	1,233,200	1,171,500	976,700	945,000	1,079,300	NA
28	1,206,400	1,211,900	1,114,500	1,063,800	979,500	1,069,000	NA
29	1,092,600	No data	1,125,800	1,142,400	948,400	1,041,500	NA
30	1,147,100	No data	1,105,900	1,115,800	1,048,500	1,061,000	NA
31	1,136,800	No data	1,107,400	No data	1,152,200	No data	NA
Total	24,772,600	33,129,700	37,814,000	32,480,500	34,384,300	33,052,600	11,786,100
Total	207,419,800						

a. NA = Not applicable.

Appendix D

Known Leaks and Releases Data

Appendix D

Known Leaks and Releases Data

D-1. INTRODUCTION

Over the course of January 11, 2005, through July 11, 2005, several leaks and/or releases have been identified. These leaks/releases include the following:

- Brine water leak
  - Treated water system brine leak discovered near CPP-1610
- Steam leak near CPP-1608
  - Steam system leak discovered near CPP-1608
- Condensate leak near CPP-666
  - Steam condensate leak discovered near CPP-666
- Potable water leak
  - Potable water leak discovered near CPP-1673
- Fire hydrant leak (Hydrant 1505)
  - Underground fire hydrant leak located on the southeast side of CPP-603
- Fire hydrant leak (Hydrant 6511)
  - Fire hydrant leak located just south of CPP-699.

Quantitative values for the amount of water released during each release event identified above are determined in the following subsections.

D-2. BRINE WATER LEAK

On February 25, 2005, a leak was identified in a line between an exterior brine tank (CPP-736) and interior water softener in CPP-606. The line runs through an underground penetration in the floor of the building. The brine was seeping through the floor penetration into the building. This brine line was not used following this date, pending a treated water system upgrade.

Due to the nature of this release, many assumptions were made to determine an approximate volume of water that was discharged to ground. These assumptions were developed by discussing the issue with the INTEC system engineer and developing acceptable parameters for determining the volume of brine released. Due to the assumptions, an elevated uncertainty was given to this number. The assumptions and volumetric release calculation are presented below.

D-2.1 Assumptions

The following assumptions were made:

- Water softener regeneration occurs ~65–70 times per month[a] or ~14.7–17.5 times per week (~2.3 times per day). **(HIGH CONFIDENCE)**
- Regeneration requires approximately 67 gpm brine water flow for approximately 6 minutes per regeneration (Shepherd 2005). **(HIGH CONFIDENCE)**
- Approximately 10–20 gpm of brine were released to ground during each regeneration. **(LOW CONFIDENCE)**
- Releases of brine to the ground began before January 11, 2005, but were assumed to have lasted 46 days. **(MEDIUM CONFIDENCE)**

D-2.2 Volumetric Release Calculation

Based on the assumptions above, the amount of brine water released to the ground between January 11, 2005, and February 25, 2005, is calculated using Equation D-1 below:

$$V_B = Q_L \times T_R \times R_R \times D \qquad \text{(D-1)}$$

where

V_B = volume of brine that leaked to the ground

Q_L = flow rate of the brine leak

T_R = amount of time brine is pumped during each regeneration

R_R = rate of regeneration

D = number of days between January 11, 2005, and February 25, 2005.

Solving for V_B, values based on the assumptions are substituted into Equation D-1,

where

Q_L = 15 gpm, with a range of 5–25 and estimated standard deviation of 5

T_R = 6 min/regeneration, with a range of 5–7 and estimated standard deviation of 0.5

R_R = 2.3 regenerations/day, with a range of 2.1–2.5 and estimated standard deviation of 0.1

D = 46 days.

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a. Phone conversation between M. D. Varvel, CWI, and T. A. Shepard, CWI, July 6, 2005.

Therefore,

$$V_B = \left(15\frac{\text{gal}}{\text{min}}\right)\times\left(6\frac{\text{min}}{\text{R}}\right)\times\left(2.3\frac{\text{R}}{\text{day}}\right)\times(46\text{ days})$$

$$V_B = 9{,}522\ \text{ gal}$$

Using the delta method, the variance of V_B is

$$\begin{aligned}\text{var}(V_B) &= \text{var}(Q_T)T_R^2R_R^2D^2 + \text{var}(T_R)Q_T^2R_R^2D^2 + \text{var}(R_R)Q_T^2T_R^2D^2 \\ &= 25\times6^2\times2.3^2\times47^2 + 0.25\times15^2\times2.3^2\times47^2 + 0.01\times15^2\times6^2\times47^2 \\ &= 3369.5^2\end{aligned}$$

and a 95% probability interval is 9,522 ± 1.96 × 3,369.5 (2,918–16,126) gal.

D-3. STEAM LEAK NEAR CPP-1608

A steam leak was discovered near CPP-1608 on October 23, 2004. The line was isolated and repair was planned for spring 2005. During the excavation of the steam line in the spring of 2005, the line was found to be still hot after being off for about 6 months. This indicated that, even though the steam line was isolated, condensate from the underground leak had entered the ground all winter, with no indication of how long this occurred before the steam leak was actually discovered. Because of this and because knowing the rate at which the leak occurred is impossible, the volume of the steam and condensate leak from this event is assumed to be adequately quantified within the range of values for the steam system losses for the INTEC water balance as discussed in Appendix F. It is also assumed that if the volume fell out of the range of steam system losses, the volume would be included in the final "unaccounted water output."

D-4. CONDENSATE LEAK NEAR CPP-666

A steam condensate leak was discovered near CPP-666 where condensate leaked to ground. The line was isolated and repair is currently being scheduled. Knowing the rate at which the leak occurred and the length of time of the leak is impossible. Because of this, the volume of condensate that leaked from this event is assumed to be adequately quantified within the range of values for the steam system losses for the INTEC water balance as discussed in Appendix F. This analysis also assumes that, if the volume fell out of the range of steam system losses, the volume would be included in the final "unaccounted water output."

D-5. POTABLE WATER LEAK

On March 29, 2005, a potable water leak was discovered when normal flow rates significantly increased by 2–3 times. By April 9, 2005, the leak was isolated and found to be near Building CPP-1673. Once isolated, potable water flows returned to normal. The potable water flow meter and data recorder captured enough data to adequately estimate the quantity of water that was discharged to ground. A statistical analysis of the data was conducted to determine the amount of water that was discharged to ground. The value and explanation of the calculation is provided below.

Flow data for the potable water were collected from January 11 through May 9, 2005, every 6 minutes (Figure D-1). A weekly cycle was evident and a leak in the system in early April was the focus of this analysis. The system appeared to be in a steady state until late March, when a slight increase in flow was observed before a sharp jump in flow. The leak was identified and isolated. After isolation, the flow returned to steady state.

To estimate the amount of water lost during this episode, the cumulative flow meter data were used (Figure D-2). The cumulative flow data showed the weekly cycles but did not mask the steady state or leak episode as did the flow data. The steady state of the cumulative flow data was represented by the slope of the line, both before and after the episode, but not during. The difference between the lines (or difference between intercepts) was an estimate of the loss of water due to the leak.

This difference was estimated by fitting a regression line to the data before and after the leak episode. The regression lines had the same slope but different intercept terms (Figure D-2). The time variable was a numeric representation of date and time, so the slope and intercepts of the regression lines did not have a straightforward temporal meaning. The regression equations were

1/11/2005–3/20/2005

$$\text{Cum. Flow} = -413{,}192{,}240 + 25{,}124 \times \text{Time}$$

4/10/2005–5/9/2005

$$\text{Cum. Flow} = -412{,}952{,}257 + 25{,}124 \times \text{Time}.$$

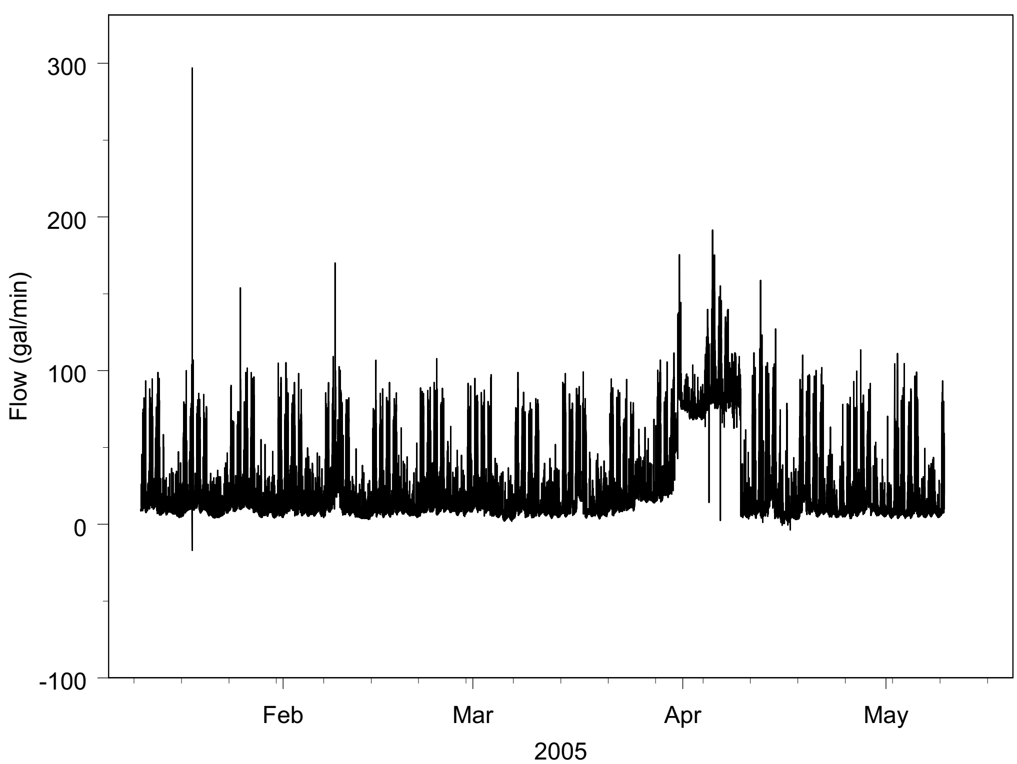

Figure D-1. Flow data for potable water.

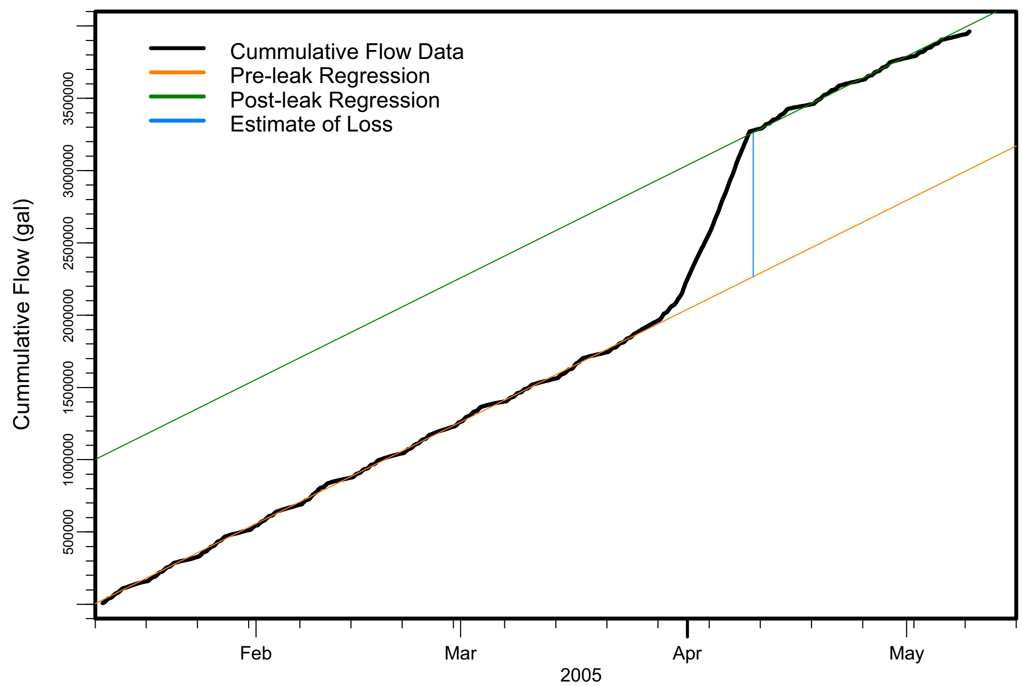

Figure D-2. Cumulative flow data for potable water and fitted regression lines.

Thus, the leak estimate, as a difference in intercepts, was 996,983 gal with a 95% confidence interval of (996,158–997,808). The confidence interval was based on the standard errors from the regression analysis. The variance for this estimated leak is 421^2.

D-6. FIRE HYDRANT LEAK (HYDRANT 1505)

During fire hydrant testing in August 2004, personnel conducting the test identified an underground leak at Hydrant 1505, located on the southeast side of CPP-603. The leak was discovered when personnel conducting fire hydrant tests could not close the hydrant adequately at the curb valve. The hydrant could not be isolated because the isolation would have cut fire water to a portion of CPP-603, which requires it for safety purposes. To determine an estimate for the amount of water that has leaked, a fire water impairment was conducted to isolate the hydrant for a period of time and monitor flow rate reduction through the fire water jockey pumps (pumps that maintain fire water system pressure). Upon isolating the hydrant, flow data were monitored and collected. Below is a statistical explanation of how the leak flow rate was determined for the hydrant.

The fire water system flow rate was recorded every 5 minutes for over 7 days (Figure D-3, black line). The goal was to estimate the difference in flow rate between isolation and normal operation. Time series analysis was used to predict flow rate during the isolation period based on normal operation prior to isolation. These predictions were then compared to the observed flow rates during isolation.

To facilitate the time series model, the data were reduced to one value every 15 minutes and extreme values (considered outliers to normal operation) were removed. The data were reduced by using the first recorded value in the 15-minute interval that was not extreme, where extreme was defined to be greater than 30 gpm. In two cases where all extreme flow rates were within the 15-minute interval, temporally close flow rates were used.

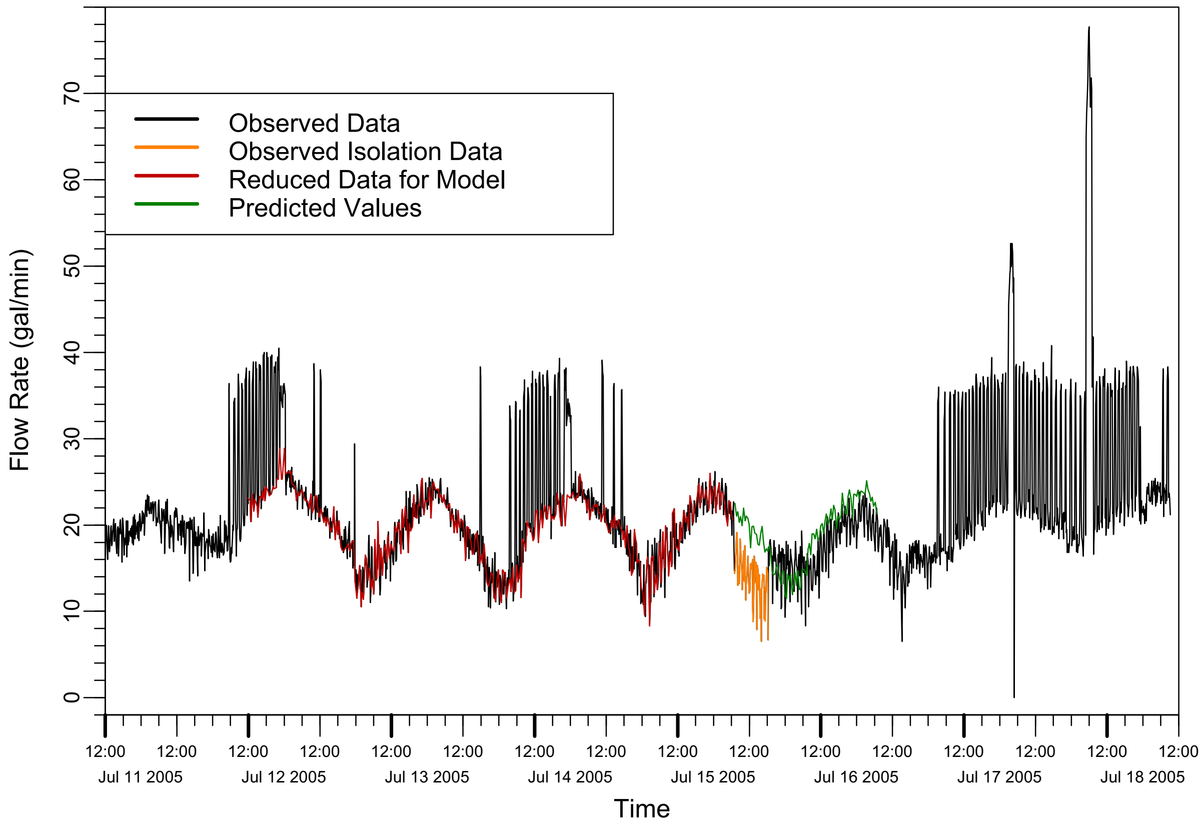

Figure D-3. Hydrant isolation data.

The reduced data were differenced once and fit with an auto-regressive moving-average (ARMA) (1,1) model with a daily cycle component. Differencing once changed the data to the difference between successive observations, which reduced the autocorrelation at lag one. The cyclic component removed the daily swing in the values (apparent in Figure D-3). The auto-regressive (1) portion of the model assumed a linear (in the parameters) regression-type behavior in the data, dependent on previous values (in this case one previous value). The moving average (1) portion of the model assumed the data values are related to previous values (in this case one previous value) by an averaging mechanism. The residuals of the model lacked temporal correlation, which was the goal of fitting a time series model.

This model was then used to predict flow rate through the isolation period and beyond. The predictions were calculated for a full day after the isolation started to compare the predictions against the observations after the isolation period ended in order to check the model (a validation of the model).

The predictions after the isolation period matched the observations fairly well. The model slightly underpredicted flow rate during the evening low-flow-rate time period and overpredicted flow rate beyond that time. For the time period directly following the isolation, the predictions matched the observations well. Prediction accuracy of a time series model decreases as time forward increases; the extrapolation gets more severe.

To estimate the difference in flow rate between predicted normal operation and the isolation period, the mean difference between observed and predicted during that time was used. The mean difference in flow rate was 5.7 gpm, with confidence interval (4.8–6.7) using only the variance among the differences, not including the model uncertainty. Time series predictions were extrapolations, so they carried with them large uncertainties. When these uncertainties were included, the confidence interval was (1.2–10.2). Because the predictions after the isolation period matched up with the observations, the model uncertainty was assumed to be an overestimate. The confidence interval based on variance between predicted and observed was used for this study.

Based on the determined flow rate of 5.7 gpm (8,208 gpd) with confidence interval (4.8–6.7) and assuming this flow rate has been constant throughout the time period of January 11, 2005, through July 11, 2005, the amount of water leaked to ground was calculated as

$$\left(8{,}208\frac{\text{gal}}{\text{day}}\right)\times\left(182\text{ days}\right)=1{,}493{,}856\text{ gal}.$$

Thus, the volume of water released from Hydrant 1505 during the time period of January 11, 2005, through July 11, 2005, was 1,493,856 gal with a confidence interval of (1,257,984–1,755,936), and variance of the estimate was $133{,}661^2$.

D-7. FIRE HYDRANT LEAK (HYDRANT 6511)

During fire hydrant testing on June 28, 2005, personnel conducting the test were unable to adequately shut off water at Hydrant 6511, located on the south side of CPP-699. A hose was attached to the hydrant and the leak was diverted to a lined ditch that leads to an evaporation pond located to the east of INTEC. To estimate the amount of water that leaked, a flow rate for the leak was determined by conducting a series of timed volume collections. This was done by collecting water from the leak for a period of 30 seconds and measuring the volume collected using a graduated cylinder. This was done 15 times for repeatability. Data collected from this event are presented in Table D-1 below.

Table D-1. Hydrant 6511 leak flow data from July 15, 2005.

Time of Collection	Volume Collected (mL)	Time Interval
7:58 a.m.	1,490	30 seconds
8:01 a.m.	1,490	30 seconds
8:04 a.m.	1,455	30 seconds
10:26 a.m.	1,440	30 seconds
10:32 a.m.	1,430	30 seconds
10:34 a.m.	1,475	30 seconds
12:35 p.m.	1,420	30 seconds
12:37 p.m.	1,370	30 seconds
12:39 p.m.	1,440	30 seconds
2:19 p.m.	1,440	30 seconds
2:21 p.m.	1,440	30 seconds
2:24 p.m.	1,440	30 seconds
4:08 p.m.	1,535	30 seconds
4:10 p.m.	1,500	30 seconds
4:11 p.m.	1,510	30 seconds

Based on the data presented in Table D-1, the rate of release with a confidence interval is determined. The slope of the regression lines were not significantly different from zero ($p = 0.54$). The five sample times, with three replicates each, were not significantly different (ANOVA $p = 0.41$).

The estimate, with confidence interval in parentheses is 1,458.3 mL/30 sec (1,435.2–1,481.4).

Converting the estimate and confidence interval above to gallons per minute, the value is 0.77 gpm (0.76–0.78).

Based on this information, the volume of water discharged from the Hydrant 6511 leak is calculated below, assuming the leak occurred from 12:00 p.m. June 28 through July 11, 2005:

$(0.77 \text{ gpm}) \times (13.5 \text{ days}) \times \left(1{,}440 \dfrac{\text{min}}{\text{day}}\right) = 14{,}969 \text{ gal}$ with a confidence interval of (14,774–15,163 gal) and variance 99^2.

D-8. LEAK SUMMATION

The volumes of output water calculated for each known leak/release calculated in the previous sections are presented in Table D-2.

Table D-2. Volume of output water.

Source	Estimated Output (gal)	Interval Estimate (gal)
Brine leak	9,522	2,918–16,126[a]
Potable water leak	996,983	996,158–997,808[b]
Hydrant 1505 leak	1,493,856	1,231,880–1,755,832[b]
Hydrant 6511 leak	14,969	14,774–15,163[b]

a. Interval estimate is based on a probability interval.

b. Interval estimate is based on a confidence interval.

Summing the above values yields an estimate of 2,515,330 gal. The probability interval for this total, based on the sum of the variances, was (2,253,270–2,777,390).

D-9. REFERENCES

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Appendix E

Evaporative Losses Data

Appendix E

Evaporative Losses Data

E-1. INTRODUCTION

Basin recharge and evaporative water losses are an unmetered output from the INTEC water system. For the purpose of this water balance, basin recharge and evaporative water losses for INTEC water systems are primarily associated with the CPP-603 basins, CPP-666 basins, and the sewage treatment lagoons. Each subsection below describes how the unmetered water losses were determined for each identified origin of the evaporation.

E-2. CPP-603 BASINS

To determine evaporative losses from CPP-603 basins that affect INTEC water system outputs for the timeframe of this water balance, the CPP-603 basins are assumed sound and not to leak based on information in EDF-2405 indicating water additions are consistent with evaporative losses. Based on this assumption, a valid conclusion is that the amount of water added to the CPP-603 basins is equal to the evaporative losses. Thus, the amount of water added to the CPP-603 basins during the timeframe of January 11, 2005, through July 11, 2005, is equal to the evaporative losses from the basins that affect this water balance. Based on information gathered from personnel performing operations in the CPP-603 basin area, water was only added once during the timeframe in consideration (Varvel 2005). Calculations for CPP-603 evaporative losses are calculated below using Equation E-1.

$$V_{E603} = A_{603} \times \left(L_2 - L_1\right) \qquad \text{(E-1)}$$

where

V_{E603} = evaporative loss affecting water balance from January 11, 2005, through July 11, 2005

A_{603} = nominal surface area of CPP-603 basins

L_1 = initial level of basin water just prior to adding water

L_2 = level of basin water just after filling.

Solving for V_{E603}, values are substituted into Equation E-1

where

A_{603} = 10,200 ft^2 (EDF-2405)

L_1 = 19 ft (Varvel 2005)

L_2 = 20 ft (Varvel 2005)

V_{E603} = $10{,}200\ \text{ft}^2 \times \left(20\ \text{ft} - 19\ \text{ft}\right)$

V_{E603} = $\left(10{,}200\ \text{ft}^3\right) \times \left(7.48\,\dfrac{\text{gal}}{\text{ft}^3}\right) = 76{,}300$ gal.

Based on the information gathered concerning the addition of water to the CPP-603 basins, the before and after water levels within the basins were right at the 19- and 20-ft level indicators when read; thus, insignificant variation or error is assumed for these numbers.

E-3. CPP-666 BASINS

To determine evaporative losses from CPP-666 basins that affect INTEC water system outputs for the timeframe of this water balance, the CPP-666 basins are assumed sound and not to leak based on no leaks being reported from the leak detection system. Demineralized water is transferred into a holding tank (VES-126) that recharges the CPP-666 basins. For the purpose of this study, the amount of demineralized water sent to VES-126 is assumed to equal the evaporative losses from CPP-666 basins during the timeframe of January 11, 2005, through July 11, 2005, that affect this water balance. While the water from VES-126 is used for other minor tasks, the tasks are considered insignificant compared to the amount that ends up in the CPP-666 basins. Based on operations logs, the amount of demineralized water sent to VES-126 during the reference time period is presented and totaled in Table E-1.

Table E-1. Summary of transfers of demineralized water from CPP-606 to VES-126 in CPP-666.

Date	Time	Volume Transferred (gal)
1/15/2005	3:40 a.m.	2,380
1/22/2005	1:30 a.m.	2,878
1/27/2005	10:30 p.m.	2,800
1/31/2005	3:30 a.m.	2,250
2/4/2005	11:20 p.m.	1,909
2/9/2005	10:20 p.m.	2,633
2/16/2005	4:33 a.m.	2,381
2/20/2005	2:00 p.m.	2,400
3/4/2005	2:50 p.m.	2,200
3/11/2005	10:20 p.m.	2,217
3/18/2005	1:17 p.m.	2,110
3/24/2005	12:15 a.m.	2,074
3/31/2005	12:00 a.m.	2,300
4/4/2005	11:55 p.m.	2,220
4/13/2005	12:10 a.m.	2,017
4/15/2005	10:10 p.m.	2,350
4/19/2005	1:30 p.m.	2,209
4/24/2005	11:55 p.m.	2,113
4/29/2005	2:35 a.m.	2,240
5/4/2005	12:20 a.m.	2,400

Table E-1. (continued).

Date	Time	Volume Transferred (gal)
5/10/2005	3:30 a.m.	1,908
5/17/2005	2:00 a.m.	3,600
5/21/2005	3:52 a.m.	2,210
5/25/2005	4:00 a.m.	2,250
5/28/2005	10:55 a.m.	2,250
5/30/2005	5:55 p.m.	2,284
6/2/2005	1:40 a.m.	2,500
6/4/2005	10:50 p.m.	2,460
6/7/2005	2:05 a.m.	2,235
6/9/2005	2:50 a.m.	2,165
6/11/2005	11:20 a.m.	2,400
6/13/2005	11:44 p.m.	2,077
6/17/2005	11:00 p.m.	2,200
6/20/2005	8:45 p.m.	2,200
6/24/2005	10:00 a.m.	2,325
6/28/2005	12:30 a.m.	2,174
6/29/2005	11:58 p.m.	2,240
7/2/2005	10:20 p.m.	2,082
7/5/2005	2:00 a.m.	2,250
7/7/2005	2:20 a.m.	2,340
7/10/2005	2:00 a.m.	2,605
	Total	94,836

Information gathered from operations logs concerning the addition of water to the CPP-666 basins are assumed accurate, thus insignificant variation or error is assumed for these numbers.

E-4. SEWAGE TREATMENT LAGOONS

The sewage treatment lagoons are located outside the northeastern security fence at INTEC. The sewage treatment lagoons consist of four ponds used to treat sanitary wastewater from INTEC. Ponds 1 and 2 are identical in size and have an approximate water surface area of 140 × 140 ft. Ponds 3 and 4 are also identical in size but are much smaller than Ponds 1 and 2. Ponds 3 and 4 have an approximate water surface area of 88 × 88 ft. Ponds 1 and 2 are aerated, promoting evaporation. While evaporation may be enhanced in the ponds, this water balance assumes that evaporation is consistent with normal evaporation rates for the area.

To determine the volume of water lost from the sewage treatment lagoons due to evaporation, evaporation rates and daily precipitation values were used. The closest location to the sewage treatment lagoons where evaporation rates are regularly recorded are from the Aberdeen Experiment Station, located in southeastern Idaho. According to *Climatography of the Idaho National Engineering Laboratory* (DOE-ID 1989), evaporation rates for INTEC can be calculated from Aberdeen Experiment Station evaporation data using a scaling factor of 0.915. Thus, using the area of surface water from the sewage treatment lagoons, daily precipitation values near INTEC, evaporation rates from the Aberdeen Experiment Station, the scaling factor previously mentioned, and a pan coefficient of 0.7 for a small pond, the volume of water evaporation is calculated with the following formula:

$$V_E = (A)[((K)(S)(E_A)) - (P)] \tag{E-2}$$

where

V_E = volume of water evaporated that affects the water balance

A = total surface area of sewage treatment ponds

K = 0.7, the small pond pan coefficient

S = 0.915 (0.86–0.97), the scaling factor for converting Aberdeen Experiment Station pan evaporation values to values for INTEC, with standard deviation of 0.029 based on the 95% confidence interval

E_A = pan evaporation value for Aberdeen Experiment Station (standard deviations based on confidence intervals (Table E-2)

P = precipitation totals for INTEC (Grid 3).

E_A values and confidence intervals were determined from the data set included in “OU 3-13 Group 1, Tank Farm Interim Action, Evaporation Pond Sizing Design” (EDF-ER-206) and are presented in Table E-2.

Table E-2. Mean monthly pan evaporation values for the Aberdeen Experiment Station.

Month	Mean E_A (1/100 in.)	95% Confidence Interval for Mean
January	0	Not applicable
February	0[a]	Not applicable
March	0[a]	Not applicable
April	453.0	(420.8–485.2)
May	763.5	(729.1–797.9)
June	895.5	(859.9–931.1)
July	1,046.6	(1,013.5–1,079.6)

a. Pan evaporation was assumed zero because the mean temperature for the month was less than 32°F.

Using Equation E-2, Table E-3 was developed to determine the evaporative losses from the sewage treatment lagoons. The confidence intervals for the V_E values were calculated using the following variance formula based on the delta method:

$$\mathrm{var}(V_E) = A^2\left[K^2\ \mathrm{var}(S)E_A^2 + K^2S^2\ \mathrm{var}(E_A)\right].$$

Table E-3. Calculated monthly evaporative losses for the INTEC sewage treatment lagoons using Equation E-2.

Month	A (ft^2)	K	S	E_A (ft)[a]	P (ft)[b]	V_E (ft^3) (confidence interval)
Jan	54,688	0.7	0.915	0	3.33 E-03	-182 (Not applicable)
Feb	54,688	0.7	0.915	0	2.50 E-03	-137 (Not applicable)
Mar	54,688	0.7	0.915	0	5.83 E-02	-3,188 (Not applicable)
Apr	54,688	0.7	0.915	0.378	6.67 E-02	9,593 (8,344–10,842)
May	54,688	0.7	0.915	0.636	2.74 E-01	7,293 (5,583–9,003)
Jun	54,688	0.7	0.915	0.746	1.03 E-01	20,498 (18,571–22,425)
Jul	54,688	0.7	0.915	0.872	0.00	10,838 (8,710–12,966)
			Total			44,715 (41,147–48,282)

a. Evaporation was prorated for January 11-31, 2005, and July 1-11, 2005.
b. Precipitation values include values from January 11, 2005, through July 11, 2005.

Converting the total volume of water evaporated from Table E-3 into gallons, the following calculation can be made:

$$V_E = \left(44{,}715\ ft^3\right)\times\left(7.48\frac{gal}{ft^3}\right) = 334{,}468\ gal.$$

E-5. EVAPORATION SUMMATION

The volumes of output water calculated for each known leak/release calculated in the previous sections are presented in Table E-4.

Table E-4. Volumes of output water.

Source	Estimate (gal)	Interval Estimate
CPP-603 basins	76,300	Not applicable
CPP-666 basins	94,836	Not applicable
Sewage treatment lagoons	334,468	(307,784–361,152)

Summing the values in Table E-4 and interval limits yields 505,604 gal (478,920–532,288).

E-6. REFERENCES

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EDF-2405, 2002, "CPP-603 Basin Water Level Review," Rev. 0, Idaho National Engineering and Environmental Laboratory, September 2002.

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Appendix F

Steam System Losses Data

Appendix F

Steam System Losses Data

Water supplied to the steam system at INTEC is fed by either recirculated steam condensate from the system or from a boiler feed makeup water supply. The amount of water supplied to the steam system from the boiler feed makeup supply line is considered the amount of water lost from the steam system during use within INTEC. Based on information from the steam system subject matter expert at INTEC, approximately 12.5% (min 5%, max 20%) of steam system losses is released to the atmosphere or to ground as normal operational releases.[a] The remaining losses are assumed discharged to the SWS or directed to the PEW Evaporator.

Totalized flow values, flow rates, date, and time are recorded approximately every 5 minutes for the boiler feed makeup water. These data are downloaded monthly and stored for later use. The total amount of steam system losses are estimated to be 12.5% of the boiler feed makeup water used for the timeframe of this water balance. The data are presented in Table F-1 below. The range is based on 5–20% of the volume assumed released.

Table F-1. Monthly boiler feed makeup totals for INTEC from January 11, 2005, through July 11, 2005.

Month	Boiler Feed Makeup (gal)	Volume Assumed Released to Ground/Atmosphere (gal) (range)
January	1,214,915	151,864 (62,568–241,161)
February	1,237,490	154,686 (63,731–245,642)
March	1,248,670	156,084 (64,307–247,861)
April	604,461	75,558 (31,130–119,986)
May	761,392	95,174 (39,212–151,136)
June	411,306	51,413 (21,182–81,644)
July	115,687	14,461 (5,958–22,964)
Total	5,593,921	699,240 (523,850–874,630)

a. Varvel, M. D. (varvmd@inel.gov), “Steam system Losses,” to T. W. Chesnovar (twc@inel.gov), July 25, 2005.

Appendix G

Minor Fire Water System Loads Data

Appendix G

Minor Fire Water System Loads Data

G-1. INTRODUCTION

Aside from providing fire protection water to the facility, the fire water system at INTEC supplies water to several minor demands and infrequent uses. The identified loads on the fire water system that are not discharged to the sanitary waste system or the SWS and affect the water balance during January 11, 2005, through July 11, 2005, include CPP-603 basin work uses, fire water testing, CPP-652 lawn irrigation, and heat pump discharges from Building CPP-697. The following sections estimate the discharges from these loads.

G-2. CPP-603 BASIN WORK USES

Work being conducted in preparation for draining the CPP-603 basins has required minor uses of fire water. These uses include filling a minimum of 10 and maximum of 15 170-ft^3 high-integrity containers (HICs) with water for training purposes and the minor use of water for decontamination purposes (Varvel 2005). For purposes of this estimate, decontamination water is considered insignificant. The calculation for determining the amount of water used for this activity was completed using the midpoint value of 12.5 for the number of HICs filled with water and is calculated below:

$$(12.5\text{ HICs}) \times \left(170\,\frac{\text{ft}^3}{\text{HIC}}\right) \times \left(\frac{7.48\text{ gal}}{\text{ft}^3}\right) = 15{,}895\text{ gal.}$$

The 95% probability interval was determined, using 1/4 the range (10–15) to estimate the standard deviation, as (12,780–19,010).

G-3. FIRE HYDRANT TESTING

Ninety-eight fire hydrants at INTEC are tested annually. Approximately 80-90 hydrants were operable for testing this year for operability during the month of June 2005 at INTEC. During the course of testing, each hydrant is opened for a minimum of 10 seconds and a maximum of 30 seconds. This water is released through a diffuser which disperses the water into the air and away from the hydrant. The release of water from the hydrants through the water diffuser is estimated to be between 1,500-1,800 gpm.

Based on the information above, using midpoints of the ranges provided, the amount of water released during fire hydrant testing is calculated as follows:

$$(85\text{ hydrants}) \times \frac{(20\,\text{sec}) \times \left(27.5\,\frac{\text{gal}}{\text{sec}}\right)}{\text{hydrant}} = 46{,}750\text{ gal.}$$

Thus, the amount of water dispersed during fire water testing is 46,750 gal. The amount of water used for testing building fire suppression is included with this number. The estimated variance of this estimate is calculated using the delta method, where individual standard deviations are estimated by 1/4 of the range, as

$$\begin{aligned}\text{Var (hydrant testing)} &= \text{var (hydrants)} \times \text{sec}^2 \times (\text{gal/sec})^2 \\ &\quad + \text{hydrants}^2 \times \text{var (sec)} \times (\text{gal/sec})^2 \\ &\quad + \text{hydrants}^2 \times \text{sec}^2 \times \text{var(gal/sec)} \\ &= 6.25 \times 20^2 \times 27.5^2 + 85^2 \times 25 \times 27.5^2 + 85^2 \times 20^2 \times 1.5625 \\ &= 11958^2.\end{aligned}$$

The 95% probability interval for the amount of water dispersed during fire water testing is 23,312–70,188 gal.

G-4. CPP-652 LAWN IRRIGATION

Water for CPP-652 lawn irrigation at INTEC is fed off of the fire water system. Information was gathered and reported in the *INTEC Water System Engineering Study* (WSES) (DOE-ID 2003) concerning water used for irrigation purposes at INTEC. The WSES report determined that approximately 5,200 gpd of water were used for irrigating the lawns at INTEC. The report wrongly assumed all lawn watering was fed off the fire water system. The only lawn fed off the fire water system is the CPP-652 lawn. Other lawns at INTEC are fed from the raw water and potable water systems. The irrigation of these other lawns is quantified in Appendix J, “Other Identified Uses Data.” For the calculation of lawn watering at INTEC, the usage rate was obtained from the *ICPP Water Inventory Study Leak Test Report* (Richards 1993). This report identified that 1.5 acres of lawn at INTEC are watered at a rate of approximately 19,971 gpd or 13,314 gal/acre/day. The approximate area of the CPP-652 lawn is 0.45 acres. Lawn watering at INTEC began approximately on June 13, 2005. Based on this information, the amount of water applied to the CPP-652 lawn for the time period of this water balance (January 11, 2005–July 11, 2005) is calculated below:

$$V_{652L} = (0.45 \text{ acres}) \times \left(13{,}314 \frac{\text{gal}}{\text{acre} * \text{day}}\right) \times (29 \text{ days}) = 173{,}748 \text{ gal.}$$

The area of the CPP-652 lawn used in this calculation was not directly measured. Two lawn areas (near CPP-663 and CPP-602) were measured and compared to the estimate obtained by the Spatial Analysis Laboratory using geographic information systems. The difference between measured and estimated was 26% and 11% for CPP-663 and CPP-602, respectively. This measurement uncertainty was used to estimate the uncertainty for the CPP-652 lawn area. Twenty-six percent of 0.45 acres results in a range of 0.33 to 0.57 acres, and an estimated standard deviation of 0.06 acres. The 95% probability interval for lawn irrigation use was calculated as 128,342–219,154 gal.

G-5. CPP-697 Heat Pump

CPP-697 utilizes two heat pumps for temperature control. One of these heat pumps discharges to the sanitary waste system and the other is directed to a French drain. Based on information obtained from an INTEC heating, ventilating, and air conditioning subject matter expert, approximately 3 to 5 gph were estimated to be required for running both heat pumps (Heyrend 2005). For the purpose of this balance, each heat pump is assumed to use half of the water demand; thus, the heat pump that discharges to ground is assumed to use 2 gph, with a range of 1.5 to 2.5 gph. For the purpose of this water balance, the heat pumps are assumed to have begun operating between May 1, 2005, and June 1, 2005, and operated daily through July 11, 2005, for 1–6 hours per day. Using the midpoint of the ranges, the pumps are assumed to have operated for 56.5 days, 3.5 hours per day, at 2 gph. The total estimated volume of water discharged to ground is calculated below:

$$V_{HP} = \left(2\,\frac{\text{gal}}{\text{hr}}\right) \times \left(3.5\,\frac{\text{hrs}}{\text{day}}\right) \times (56.5\ \text{days}) = 396\ \text{gal.}$$

The standard deviations of the components were estimated as 1/4 the range of values. These standard deviations, 0.25 gph, 7.75 days, and 1.25 hours per day, were used through the delta method to determine the variance of V_{HP} and thus a probability interval for the total volume of water discharged to ground from the heat pump:

$$\begin{aligned} \mathrm{var}(V_{HP}) &= \mathrm{var}\left(\frac{gal}{hr}\right) \times \left(\frac{hrs}{day}\right)^2 \times (days)^2 + \left(\frac{gal}{hr}\right)^2 \times \mathrm{var}\left(\frac{hrs}{day}\right) \times (days)^2 + \left(\frac{gal}{hr}\right)^2 \times \left(\frac{hrs}{day}\right)^2 \times \mathrm{var}(days) \\ &= 0.25^2 \times 3.5^2 \times 56.5^2 + 2^2 \times 1.25^2 \times 56.5^2 + 2^2 \times 3.5^2 \times 7.75^2 \\ &= 159^2 \end{aligned}$$

The 95% probability interval is then calculated as 396 ± 1.96 × 159 = (84–708).

G-6. REFERENCES

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Appendix H

Diesel Water Pump Cooling Data

Appendix H

Diesel Water Pump Cooling Data

H-1. INTRODUCTION

During the time period of January 11, 2005, through July 11, 2005, there are several known instances when cooling water from the fire water and raw water diesel water pumps discharged to ground. These instances include the weekly operational checks of the fire water diesel pumps, monthly operational checks of the raw water diesel pump, and cooling water used during fire hydrant testing at INTEC. The gland leak-off from the diesel fire water pumps is also quantified.

H-2. DIESEL FIRE WATER PUMPS

To determine the times when the diesel fire water pumps are in use, an assessment of the flow data collected from the fire water jockey pumps was made. Whenever the diesel fire water pumps turn on, water supplied to the fire water system does not route through the jockey pumps; hence, the flow readings for these times are zero. Also, fire water system pressure must be maintained. Because fire water system pressure is mandatory and at least a minor water load is usually being pulled from the fire water system, a valid assumption is that whenever the jockey pump flow rate is zero, the diesel fire water pumps are running. During these times, cooling water from the fire water diesel pumps is discharged to an unlined ditch.

Also, leak-off occurs from the packing glands of the diesel fire water pumps. This flow rate is assumed to be constant. A test was conducted to determine the flow of this leak-off by collecting water from the leak-off for 30 seconds and then measuring the amount of water captured using a graduated cylinder. This was repeated five times throughout a day, collecting volumes in triplicate each time to obtain a data set for error analysis.

H-2.1 Diesel Fire Water Pump Cooling Water

Discharges from the fire water diesel pumps and gland leak-off are calculated and presented in Table H-1.

Table H-1. Diesel fire water pump run times.

		Time Duration[b] (Minutes)		
Date	Logged Time Diesel Pump was Running[a]	Minimum Bound	Best Estimate	Maximum Bound
1/21/2005	11:10 a.m.–12:15 p.m.	65	70	75
1/30/2005	9:40 a.m.–10:40 a.m.	60	65	70
1/31/2005	9:25 a.m.–10:05 a.m.	40	45	50
2/2/2005	12:15 p.m.–12:20 p.m.	5	10	15
2/7/2005	3:55 p.m.–4:05 p.m.	10	15	20
2/13/2005	9:10 a.m.–10:05 a.m.	55	60	65

Table H-1. (continued).

Date	Logged Time Diesel Pump was Running[a]	Time Duration[b] (Minutes) Minimum Bound	Best Estimate	Maximum Bound
2/20/2005	9:50 a.m.–10:50 a.m.	60	65	70
2/21/2005	2:15 p.m.–3:05 p.m.	50	55	60
3/6/2005	11:25 a.m.–12:25 p.m.	60	65	70
3/8/2005	8:45 a.m.–10:40 a.m.	115	120	125
3/8/2005	1:10 p.m.–2:50 p.m.	100	105	110
3/13/2005	11:00 a.m.–11:55 a.m.	55	60	65
3/13/2005	8:40 p.m.–8:45 p.m.	5	10	15
3/14/2005	1:10 p.m.–1:30 p.m.	20	25	30
3/16/2005	7:55 a.m.–8:15 a.m.	20	25	30
3/20/2005	2:55 p.m.–3:50 p.m.	55	60	65
3/27/2005	11:55 a.m.–12:45 p.m.	50	55	60
4/3/2005	3:35 p.m.–4:25 p.m.	50	55	60
4/6/2005	2:05 p.m.–3:10 p.m.	65	70	75
4/7/2005	10:20 a.m.–10:35 a.m.	15	20	25
4/10/2005	8:45 a.m.–9:40 a.m.	55	60	65
4/13/2005	9:25 a.m.–10:25 a.m.	60	65	70
4/17/2005	8:55 p.m.–9:10 p.m.	15	20	25
4/18/2005	9:20 a.m.–9:55 a.m.	35	40	45
4/18/2005	10:15 a.m.–10:25 a.m.	10	15	20
4/18/2005	2:10 p.m.–3:00 p.m.	50	55	60
4/19/2005	8:35 a.m.–9:40 a.m.	65	70	75
4/19/2005	3:40 p.m.–3:45 p.m.	5	10	15
4/20/2005	1:30 p.m.–1:35 p.m.	5	10	15
4/20/2005	2:25 p.m.–2:30 p.m.	5	10	15
4/24/2005	9:40 a.m.–10:30 a.m.	50	55	60
4/30/2005	1:20 p.m.–2:15 p.m.	55	60	65
5/6/2005	4:30 p.m.–6:20 p.m.	110	115	120
5/6/2005	10:15 p.m.–11:55 p.m.	100	105	110
5/7/2005	12:00 a.m.–2:25 a.m.	145	150	155
5/13/2005	9:45 a.m.–11:30 a.m.	105	110	115
5/15/2005	9:10 a.m.–10:05 a.m.	55	60	65

Table H-1. (continued).

Date	Logged Time Diesel Pump was Running[a]	Time Duration[b] (Minutes) Minimum Bound	Best Estimate	Maximum Bound
5/17/2005	9:45 a.m.–10:25 a.m.	40	45	50
5/17/2005	1:10 p.m.–2:45 p.m.	95	100	105
5/22/2005	8:25 a.m.–9:15 a.m.	50	55	60
5/23/2005	8:50 a.m.–10:50 a.m.	120	125	130
6/21/2005	10:25 a.m.–11:10 a.m.	45	50	55
6/21/2005	2:00 p.m.–4:00 p.m.	120	125	130
6/22/2005	9:40 a.m.–10:30 a.m.	50	55	60
6/23/2005	9:30 a.m.–9:50 a.m.	20	25	30
6/23/2005	10:00 a.m.–11:00 a.m.	60	65	70
6/23/2005	1:15 p.m.–3:55 p.m.	160	165	170
6/24/2005	8:25 a.m.–11:20 a.m.	175	180	185
6/26/2005	10:05 a.m.–11:00 a.m.	55	60	65
6/27/2005	9:05 a.m.–10:30 a.m.	145	150	155
6/27/2005	1:00 p.m.–4:10 p.m.	190	195	200
6/28/2005	8:20 a.m.–9:00 a.m.	40	45	50
6/29/2005	8:45 a.m.–9:20 a.m.	35	40	45
6/29/2005	9:30 a.m.–10:00 a.m.	30	35	40
6/29/2005	10:25 a.m.–10:35 a.m.	10	15	20
6/29/2005	1:20 p.m.–3:30 p.m.	130	135	140
7/3/2005	9:20 p.m.–9:25 p.m.	5	10	15
7/6/2005	9:40 a.m.–10:25 a.m.	45	50	55
7/6/2005	10:35 a.m.–11:35 a.m.	60	65	70
7/10/2005	8:00 p.m.–9:00 p.m.	60	65	70
	Total	3,620	3,920	4,220

a. Diesel fire water pump usage was only considered valid when the fire water jockey pumps indicated zero flow for at least two consecutive data points (data collected every 5 minutes).
b. Each time interval the pump was running has a maximum ± 5-minute tolerance.

Based on the total times listed in Table H-1, the best estimate time of 3,920 minutes is used for calculating the total volume of water discharged. The number of minutes for each time duration was assumed to follow a uniform distribution with limits equal to the minimum and maximum. The variance of a uniform distribution is the range squared divided by 12. The minimum and maximum is assumed to be just short of 5 minutes on either side of the best estimate, resulting in a practical range of 9.8 and a variance of 8.003. The sum of these 60 observations was also assumed to follow a uniform distribution with limits equal to the sum of the minimum and maximum for all time durations (3,620 and 4,220 minutes). The sum of the best estimates and sum of variances were used to determine a 95% confidence interval of 3,877–3,963 minutes, based on Equation H-1.

$$\sum_{i=1}^{60} X_i \pm z_{0.975} \frac{\sqrt{\sum_{i=1}^{60} \mathrm{var}(X_i)}}{n} = 3920 \pm 1.96 \frac{\sqrt{60 \times 8.003}}{60}, \qquad \text{(H-1)}$$

where

X_i = time durations

$z_{0.975}$ = 97.5th percentile of the standard normal distribution

n = 60.

The rate of discharge for cooling the diesel fire water pumps was determined based on interviews with plant utility operations personnel and based on flow data collected from a flume in the unlined ditch into which the cooling water is discharged. Based on interviews, operators estimate the cooling water flows to be approximately 30–40 gpm. Based on flow data from a flume currently placed in the ditch where cooling water is discharged, flows ranged from 30–60 gpm, with a typical rate of approximately 40 gpm. Based on the information gathered from utility operations personnel and actual field data, the flow rate for calculating the amount of water discharged is 40 gpm, with a range of 30–60 gpm, resulting in a standard deviation estimate of 7.5.

Based on this information, the total cooling water discharge from the diesel fire water pumps during the time period of January 11, 2005, through July 11, 2005, is calculated below:

$$(40\ \text{gpm}) \times (3{,}920\ \text{min}) = 156{,}800\ \text{gal.}$$

The probability interval (99,150–214,450) was calculated using a variance estimate based on the delta method:

$$156{,}800 \pm 1.96 \times \sqrt{40^2 \times (60 \times 8.003) + 7.5^2 \times 3{,}920^2}\ .$$

H-2.2 Diesel Fire Water Pump Gland Leak-off

To determine the amount of water discharged from the gland leak-off, a flow test was conducted on the release. The gland leak-off is assumed to release at a constant flow throughout the year. Flow measurements were conducted throughout the day on July 15, 2005. Data collected from this event are presented in Table H-2.

Based on the data presented in Table H-2, the rate of release with a confidence interval is determined. The slope of the regression line was not significantly different from zero ($p = 0.58$); and the five sample times, with three replicates each, were not significantly different (ANOVA $p = 0.58$).

Table H-2. Gland leak-off flow data from July 15, 2005.

Time of Collection	Volume Collected (mL)	Time Interval
7:49 a.m.	290	30 seconds
7:51 a.m.	290	30 seconds
7:52 a.m.	310	30 seconds
10:10 a.m.	300	30 seconds
10:13 a.m.	300	30 seconds
10:15 a.m.	295	30 seconds
12:24 p.m.	285	30 seconds
12:26 p.m.	300	30 seconds
12:27 p.m.	300	30 seconds
2:12 p.m.	300	30 seconds
2:13 p.m.	305	30 seconds
2:14 p.m.	300	30 seconds
4:00 p.m.	300	30 seconds
4:02 p.m.	300	30 seconds
4:03 p.m.	295	30 seconds

The estimate, with confidence interval in parentheses, is 298 mL/30 sec (294.6–301.4).

Converting the estimate and confidence interval above to gallons per minute, the value is 0.157 gpm (0.155–0.159).

Based on this information, the gland leak-off discharge from the diesel fire water pumps during the time period of January 11, 2005, through July 11, 2005, is calculated below:

$$(0.157 \text{ gpm}) \times (182 \text{ days}) \times \left(1{,}440 \frac{\text{min}}{\text{day}}\right) = 41{,}147 \text{ gal.}$$

The confidence interval is (40,622 gal–41,670 gal).

H-3. DIESEL RAW WATER PUMP

The diesel raw water backup pumps are not used as frequently as the diesel fire water pumps. These pumps were assumed to be used only during monthly operational checks during the defined time period of this balance. Based on interviews with utility operations personnel, the cooling water discharge from the raw water backup pump was estimated to be approximately 25–35 gpm, with a best estimate of 30 gpm and estimated standard deviation of 2.5. Based on engine run time recordings from utilities operational logs for the reference time period, the raw water backup pumps ran for a total of 4.5 hours with a range of (4–5 hr) and estimated standard deviation of 0.25. Based on this information, the amount of water discharged from the raw water backup pumps is calculated below:

$$(30\text{ gpm})\times(4.5\text{ hr})\times\left(60\,\frac{\text{min}}{\text{hr}}\right)=8{,}100\text{ gal.}$$

The probability interval (6,510–9,690) was calculated based on the variance from the delta method:

$$8{,}100\pm 1.96\sqrt{60^2(2.5^2\times 4.5^2+30^2\times 0.25^2)}\,.$$

H-4. OVERALL DIESEL WATER PUMP COOLING DISCHARGES

The overall water discharged by the diesel fire water and raw water pumps for the time period of January 11, 2005, through July 11, 2005, is summed below from the data presented in the previous sections.

$$(156{,}800\text{ gal})+(41{,}147\text{ gal})+(8{,}100\text{ gal})=206{,}047\text{ gal.}$$

The probability interval is calculated based on the sum of the variances as 148,373–263,721 gal.

Appendix I

Septic Systems Data

Appendix I

Septic Systems Data

Three buildings within INTEC utilize active septic systems. These buildings are CPP-656, CPP-655, and CPP-626. To determine the amount of water discharged to each septic system, Table I-1 was developed to estimate water use values for each building.

Table I-1. Information for estimating discharges for each active septic system within INTEC.

	Typical Occupancy Range[a]		Water Usage Values[b]	
Building	Monday–Thursday	Friday–Sunday	Range	Typical Value
CPP-656	25–50 people	0–5 people	8-20 gal/person/day	15 gal/person/day
CPP-655	2–12	0	8-20 gal/person/day	15 gal/person/day
CPP-626	6–10	0–4	8-20 gal/person/day	15 gal/person/day

a. Building occupancy ranges vary because normal operating days at INTEC are Monday – Thursday. These occupancy ranges are for the time period of this water balance. Occupancy/usage of CPP-626 was increased due to the amount of work in the vicinity and people using CPP-626 restroom facilities.
b. Water usage values were obtained from Metcalf and Eddy (1991) for office employee water use. (Metcalf and Eddy, 1991, *Wastewater Engineering, Treatment, Disposal and Reuse*, Third Edition, Boston: Irwin/McGraw-Hill, Inc.)

Based on information presented in Table I-1, the amount of water discharged to septic systems during the timeframe for this water balance was calculated and is presented below in Table I-2.

Table I-2. Estimated discharges for each active septic system within INTEC.

	Typical Septic Discharges[a]			
Building	Monday–Thursday	Friday–Sunday[b]	Total Discharges Between 1/11/05–7/11/05 (102 days for M-T, 80 days for F-S)	95% Probability Interval
CPP-656	562.5 gpd	37.5 gpd	60,375 gal	30,928–89,822
CPP-655	105 gpd	0 gpd	10,710 gal	2,117–19,303
CPP-626	120 gpd	30 gpd	14,640 gal	8,442–20,838
		Total	85,725 gal	54,430–117,020

a. Assuming a symmetric distribution, the midpoint values for the ranges in Table I-1 were used to calculate septic discharges.
b. Septic discharges during holidays are assumed to be the same as for Friday-Sunday.

Appendix J

Other Identified Uses Data

Appendix J

Other Identified Uses Data

J-1. INTRODUCTION

Other uses of water from INTEC not provided with the other categories include liquids sent to the PEW Evaporator, water used at the ICDF, and water used in evaporative coolers.

J-2. PEW USES

Wastewater sent to the PEW Evaporator is considered an output from INTEC water systems because a large majority of this water is evaporated and sent to the atmosphere, and the remainder is sent to waste storage. Based on a review of transfers of liquid wastewater sent to the PEW Evaporator from January 11, 2005, through July 11, 2005, Table J-1 was produced. For the purpose of the water balance, all wastewater transferred to the PEW Evaporator is assumed to be water that affects the balance for the specified time period. Due to the nature of the liquids being handled by the PEW Evaporator, variances for the values recorded in Table J-1 are assumed to be negligible.

Table J-1. Monthly transfer totals of liquid wastewater sent to the PEW Evaporator from January 11, 2005, through July 11, 2005.

Month	Volume of Liquid Wastewater Sent to PEW Evaporator (gal)
January	64,923
February	19,282
March	55,597
April	12,581
May	40,191
June	28,673
July	23
Total	221,270

J-3. ICDF USES

ICDF uses raw water for managing the landfill facility. The evaporation pond typically requires a large volume of makeup water for management purposes, but, for this year, the use of water from INTEC water systems was not needed for this purpose until the later part of July. Based on information gathered from operations personnel at ICDF, for the period of time between January 11, 2005, through July 11, 2005, raw water was used at a rate of approximately 800 gpd for waste management and management of the facility starting at the beginning of July 2005 (Chipman 2005). ICDF is normally operational Monday through Thursday; thus, the number of days for this rate of application is four, due to weekends and holidays. Therefore, the volume of water used by ICDF that affects the water balance is 3,200 gal. A probability interval was not determined for this value because the interval is assumed to be insignificant when compared to the overall balance.

J-4. EVAPORATIVE COOLER USES

Evaporative coolers are used on several buildings within INTEC. These coolers are sources of water output from the INTEC water system. Table J-2 lists buildings that use evaporative coolers and the square footage for each building. Based on information obtained from an INTEC heating, ventilating, and air conditioning subject matter expert, approximately 506-712 gph are required to cool 111,500 ft^2 of buildings at INTEC (Heyrend 2005). Based on this information, the water usage rate per square foot is approximately 0.0045-0.0064 gph/ft^2. To determine the amount of water lost to the environment from evaporative coolers at INTEC from January 11, 2005, through July 11, 2005, evaporative cooler use for 2005 is assumed to have begun between May 1, 2005, and June 1, 2005. Use of the coolers is assumed to have been between 1 and 6 hours per day. Using the midpoint values for these ranges, along with the total square footage of buildings that use evaporative coolers at INTEC, the amount of water used for evaporative cooling at INTEC was calculated as follows:

$$V_{EC} = \left(0.00545 \frac{gal}{hr * ft^2}\right) \times \left(3.5 \frac{hr}{day}\right) \times (56.5 days) \times \left(117{,}703 ft^2\right) = 126{,}853 gal .$$

The standard deviations for the usage rate, hours per day of usage, and number of days used are estimated by 1/4 of the range of values. These are combined using the delta method to estimate the variance of V_{EC} and calculate the 95% probability interval of 29,294 to 224,412 gal:

$$\begin{aligned} \operatorname{var}(V_{EC}) &= \operatorname{var}\left(\frac{gal}{hr \times ft^2}\right) \times \left(\frac{hr}{day}\right)^2 \times (days)^2 \times \left(ft^2\right)^2 + \\ &\quad \left(\frac{gal}{hr \times ft^2}\right)^2 \times \operatorname{var}\left(\frac{hr}{day}\right) \times (days)^2 \times \left(ft^2\right)^2 + \left(\frac{gal}{hr \times ft^2}\right)^2 \times \left(\frac{hr}{day}\right)^2 \times \operatorname{var}(days)^2 \times \left(ft^2\right)^2 \\ &= 0.000475^2 \times 3.5^2 \times 56.5^2 \times 117{,}703^2 + \\ &\quad 0.00545^2 \times 1.25^2 \times 56.5^2 \times 117{,}703^2 + 0.00545^2 \times 3.5^2 \times 7.75^2 \times 117{,}703^2 \\ &= 49{,}775^2 \end{aligned}$$

Table J-2. Square footage of buildings identified at INTEC that utilize evaporative coolers.

Building	Square Footage
CPP-699	11,562
CPP-630	21,510
CPP-606	14,921
CPP-663	64,197
CPP-653	5,043
CPP-609	470
Total	117,703

J-5. OTHER LAWN IRRIGATION

Water for irrigation of lawns, other than the CPP-652 lawn, at INTEC is fed off of the raw water and potable water systems. Specifically, lawns around CPP-1604, -1605, and -663 are fed off the raw water system, and the lawn just west of CPP-602 is fed from potable water. Information was gathered and reported in the *INTEC Water System Engineering Study* (WSES) (DOE-ID 2003) concerning water used for irrigation purposes at INTEC. The WSES report determined that approximately 5,200 gpd of water were used for irrigating the lawns at INTEC. The report wrongly assumed all lawn watering was fed off the fire water system. The only lawn fed off the fire water system is the CPP-652 lawn. The irrigation of this lawn is quantified in Appendix G, "Minor Fire Water System Loads Data." For the calculation of lawn watering at INTEC, the usage rate was obtained from the *ICPP Water Inventory Study Leak Test Report* (Richards 1993). This report identified that 1.5 acres of lawn at INTEC are watered at a rate of approximately 19,971 gpd or 13,314 gal/acre/day. The estimated amount of remaining lawn, excluding the CPP-652 lawn, is 0.77 acres. Lawn watering at INTEC began approximately June 13, 2005. Based on this information, the amount of water applied to the lawns other than the CPP-652 lawn for the time period of this water balance (January 11, 2005 – July 11, 2005) is calculated below:

$$V_L = (0.77 \ \text{acres}) \times \left(13{,}314 \frac{\text{gal}}{\text{acre} * \text{day}}\right) \times (29 \ \text{days}) = 297{,}302 \ \text{gal.}$$

The area of lawn at the INTEC used for this calculation was not directly measured. Two lawn areas (near CPP-663 and CPP-602) were measured and compared to the estimate obtained by the Spatial Analysis Laboratory using geographic information systems. The difference between measured and estimated was 26% and 11% for CPP-663 and CPP-602, respectively. This measurement uncertainty was used to estimate the uncertainty for the lawn area for this calculation. Twenty-six percent of 0.77 acres results in a range of 0.57 to 0.97 acres, and an estimated standard deviation of 0.05 acres. The 95% probability interval for lawn irrigation use was calculated as 259,463–335,140 gal.

J-6. REFERENCES

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DOE-ID, 2003, *INTEC Water System Engineering Study*, DOE/ID-11115, Rev. 0, U.S. Department of Energy Idaho Operations Office, December 2003.

Heyrend, R. R. (hr2@inel.gov), "New Evap Data," to M. D. Varvel (varvmd@inel.gov), August 4, 2005.

Richards, B. T., 1993, *ICPP Water Inventory Study Leak Test Report*, WINCO-1182, Idaho National Engineering Laboratory, December 1993.

Appendix K

INTEC Water Systems

Drawings included in this appendix are as follows:

056265
056593
056266
093126
056570
056980
056507
056264

Appendix K

INTEC Water Systems

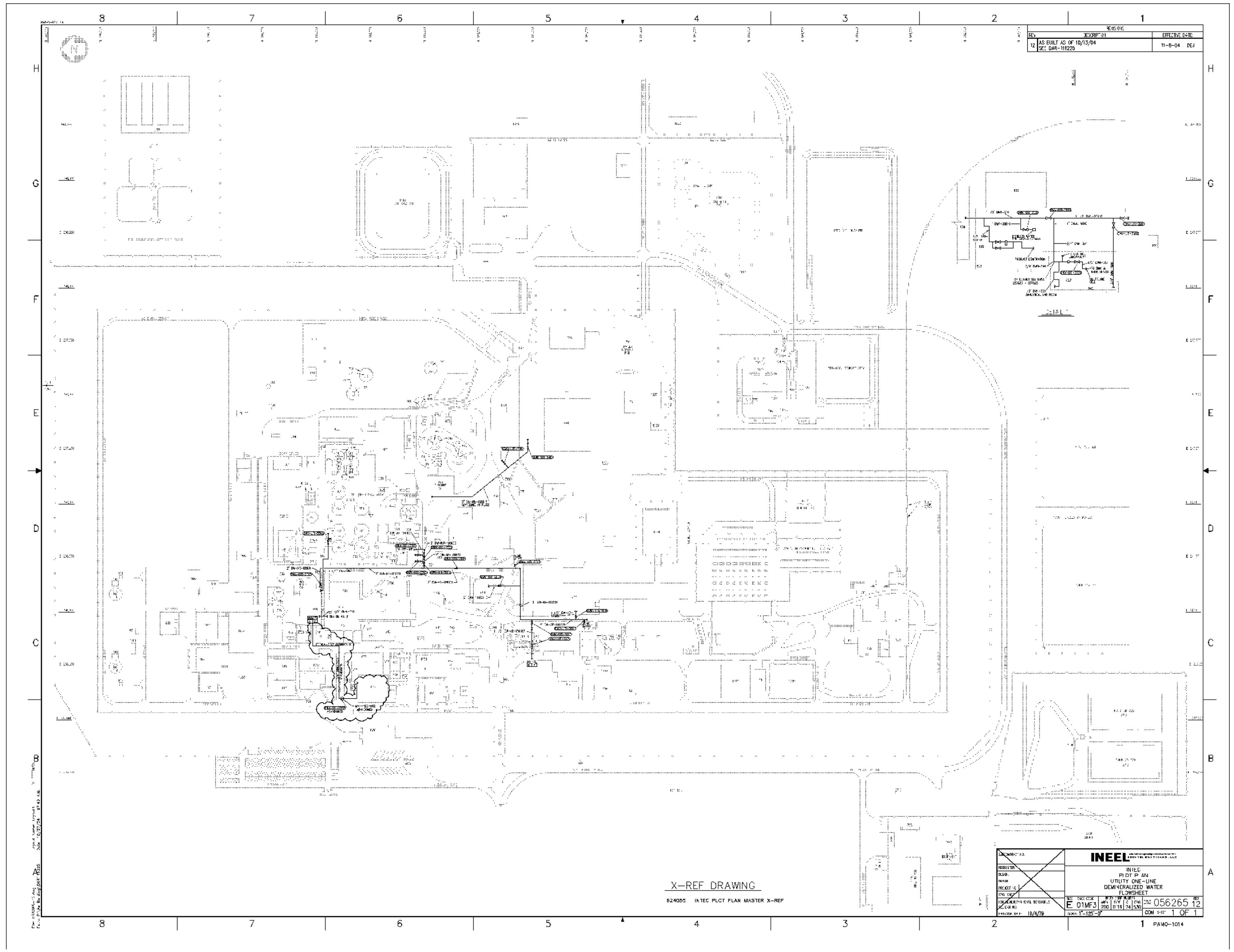

Figure K-1. Flowsheet for the Idaho Nuclear Technology and Engineering Center plot plan utility one-line demineralized.

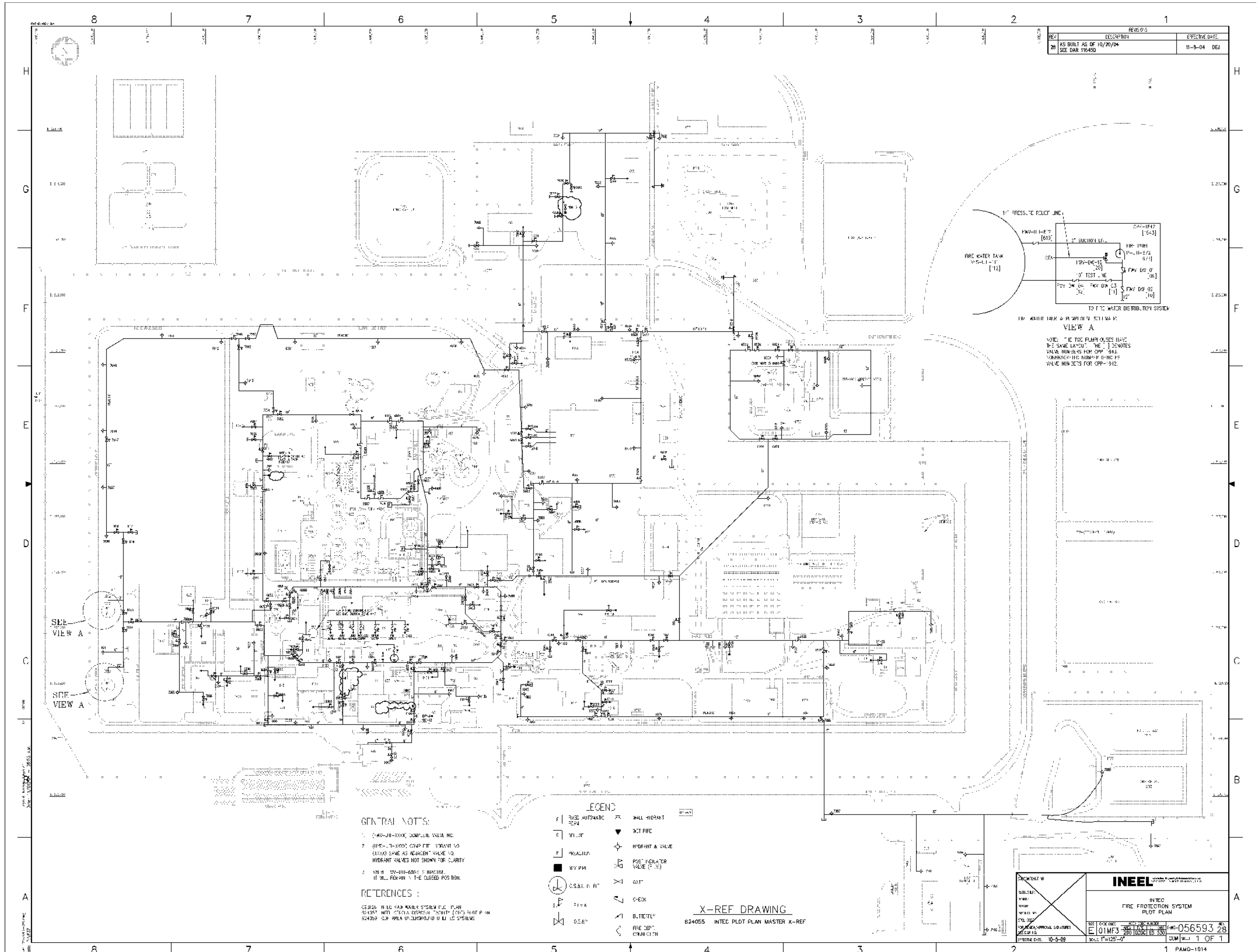

Figure K-2. Plot plan for the Idaho Nuclear Technology and Engineering Center fire protection system.

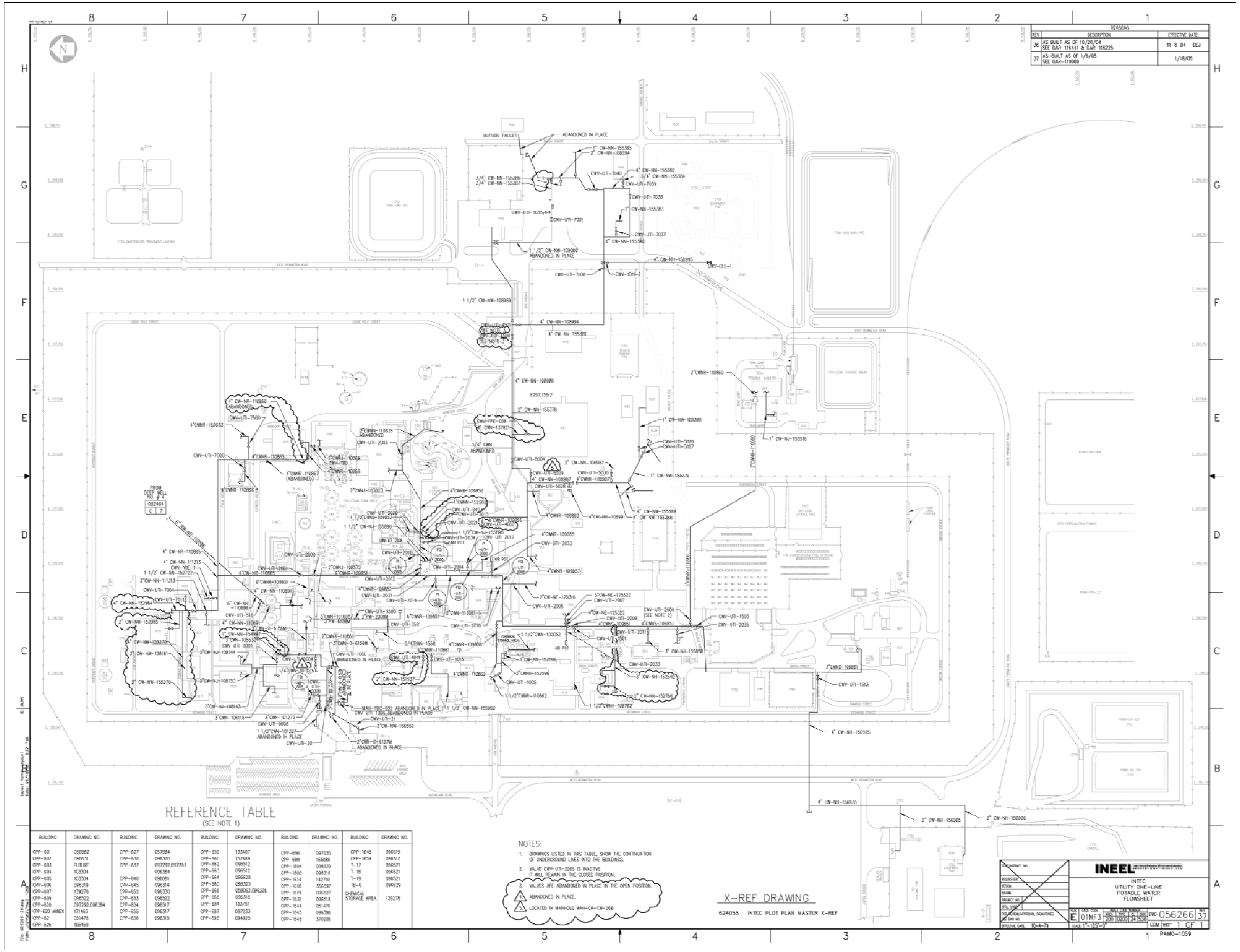

Figure K-3. Flowsheet for the Idaho Nuclear Technology and Engineering Center utility one-line potable water.

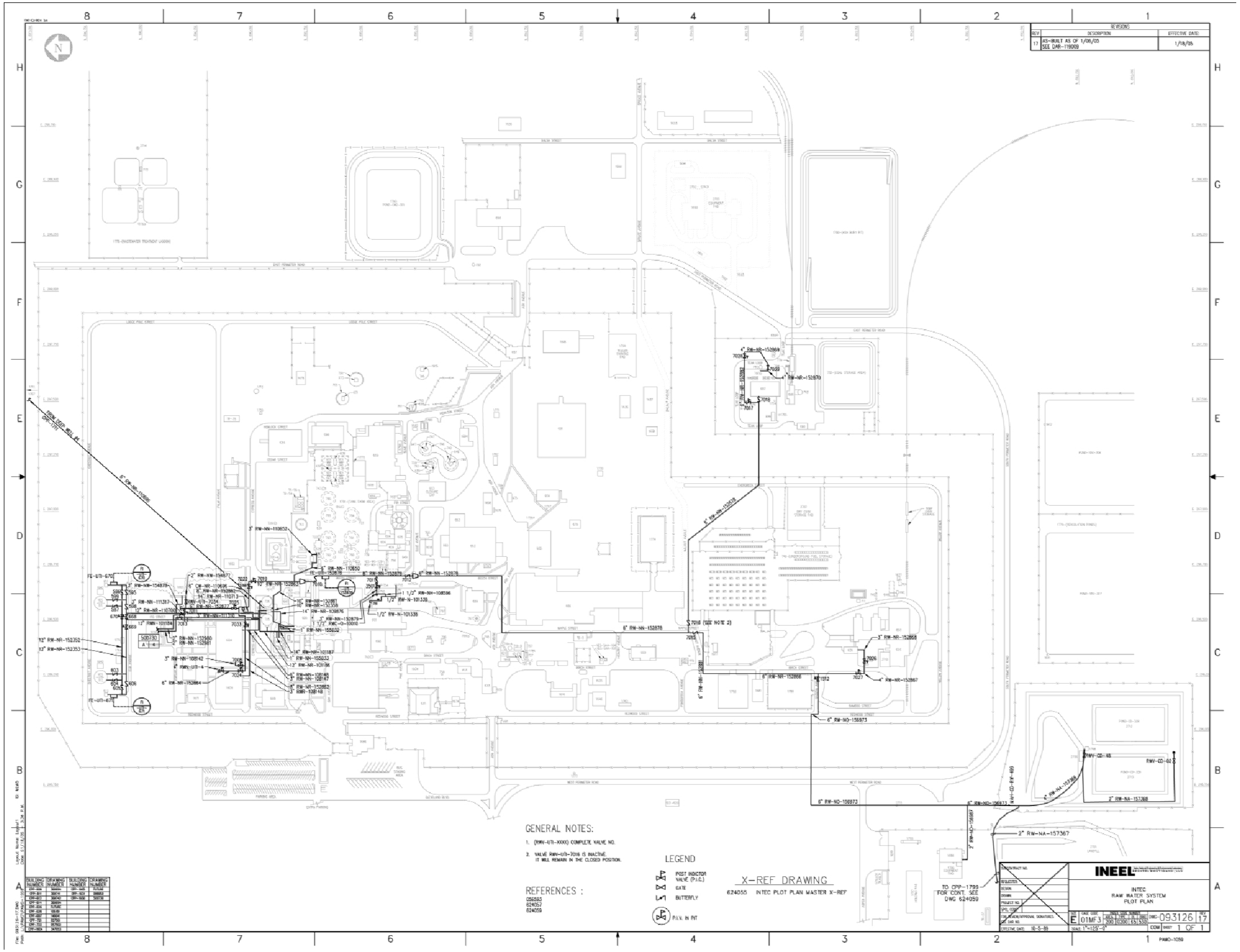

Figure K-4. Plot plan for the Idaho Nuclear Technology and Engineering Center raw water system.

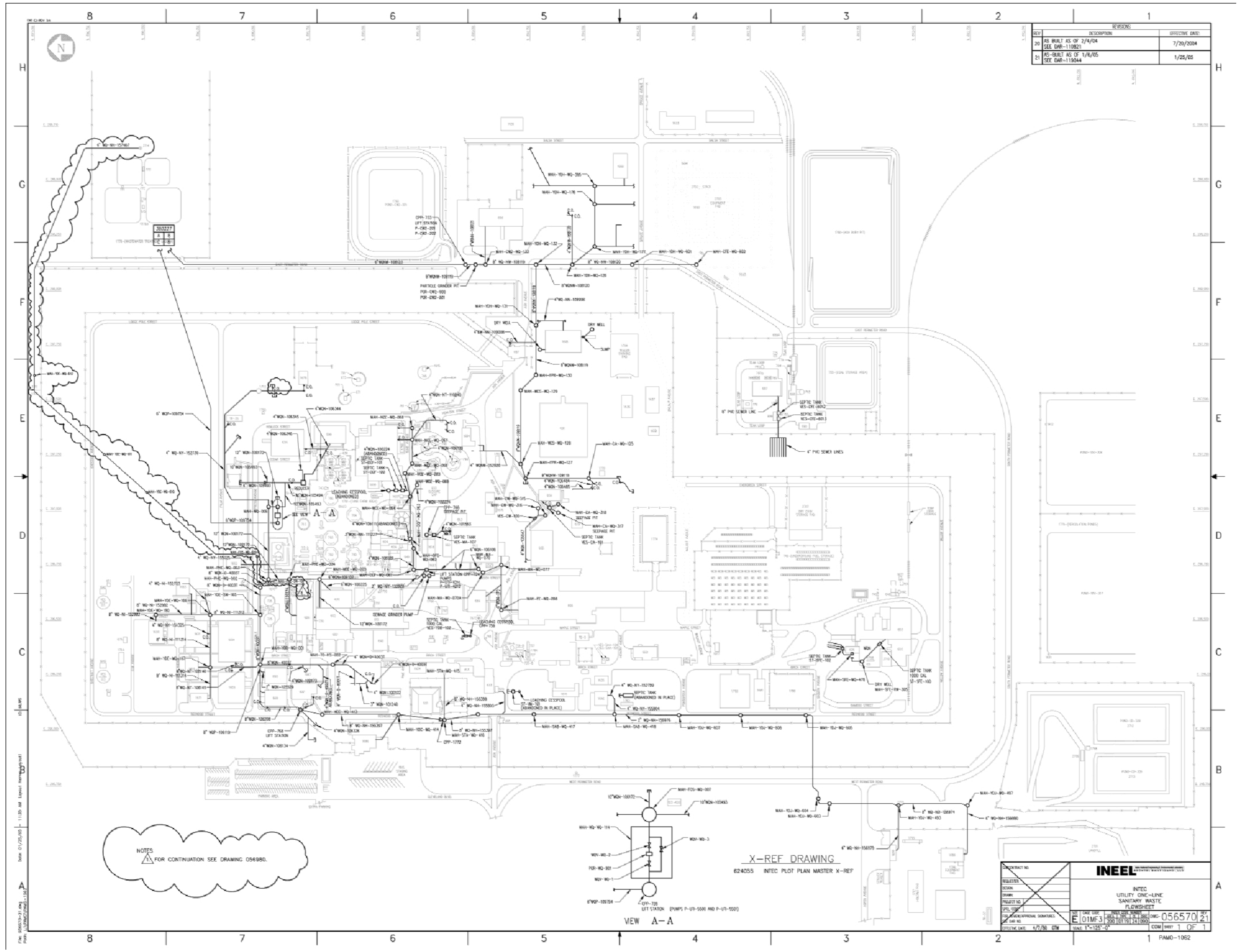

Figure K-5. Flowsheet for the Idaho Nuclear Technology and Engineering Center utility one-line sanitary waste.

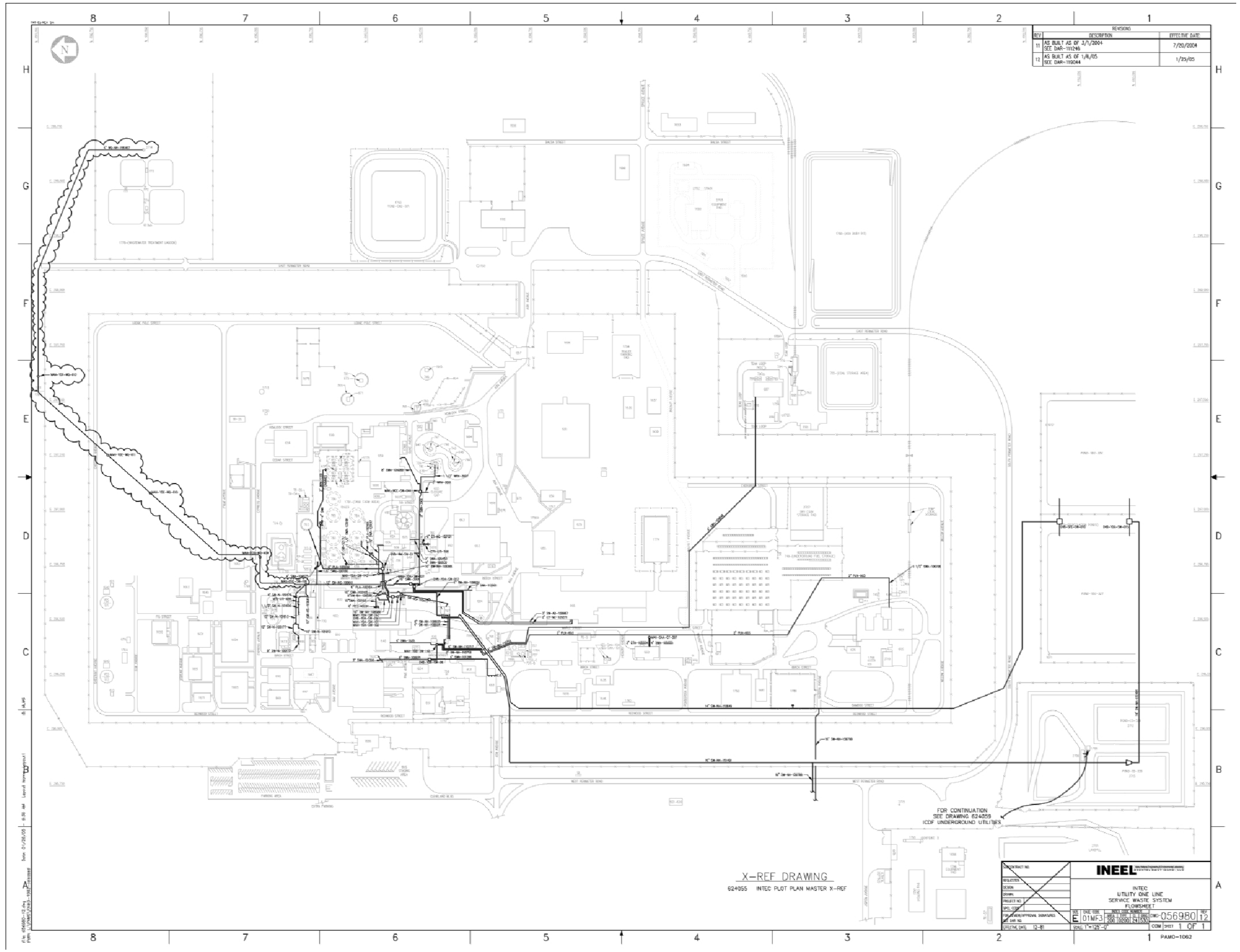

Figure K-6. Flowsheet for the Idaho Nuclear Technology and Engineering Center utility one-line service waste system.

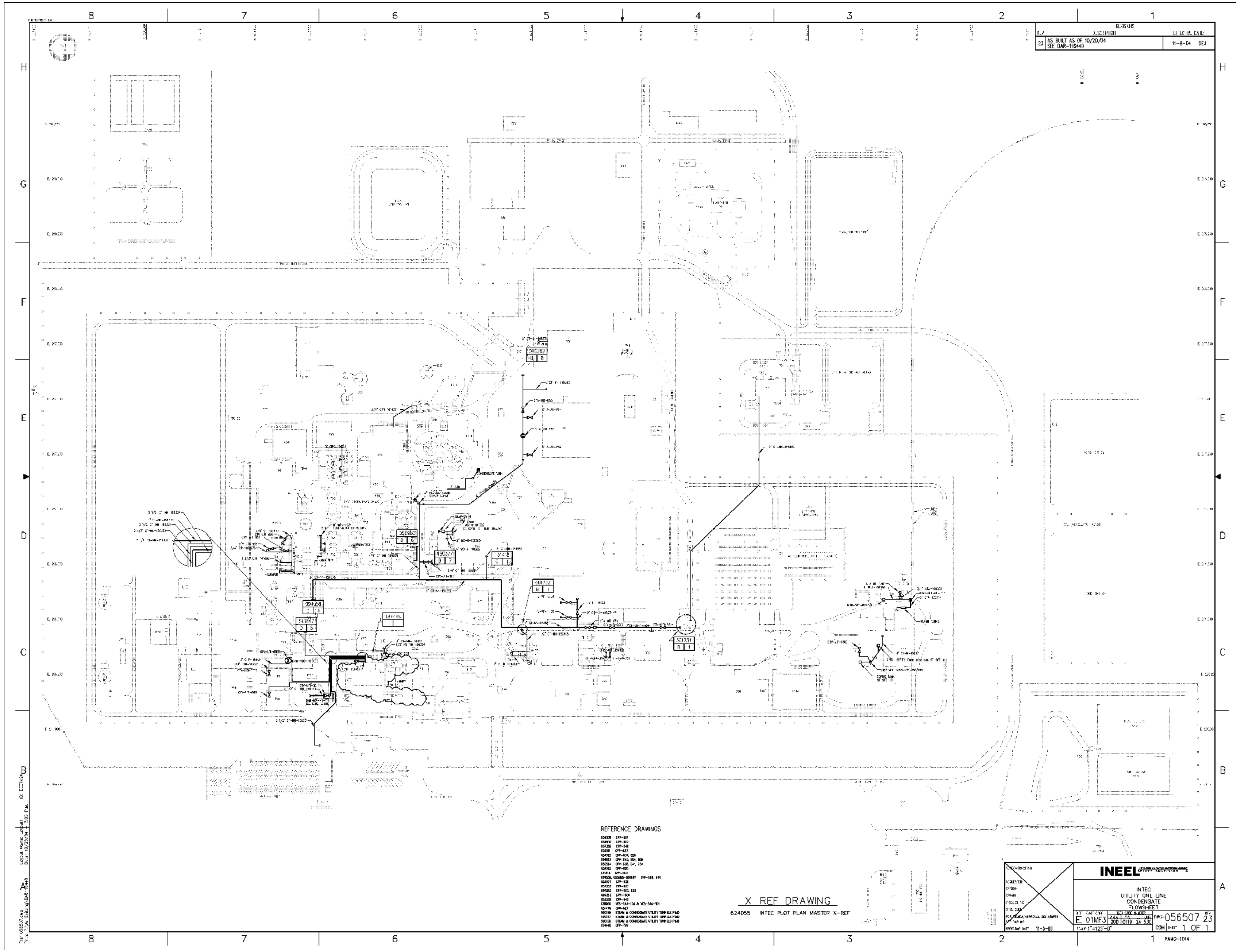

Figure K-7. Flowsheet for the Idaho Nuclear Technology and Engineering Center utility one-line steam condensate.

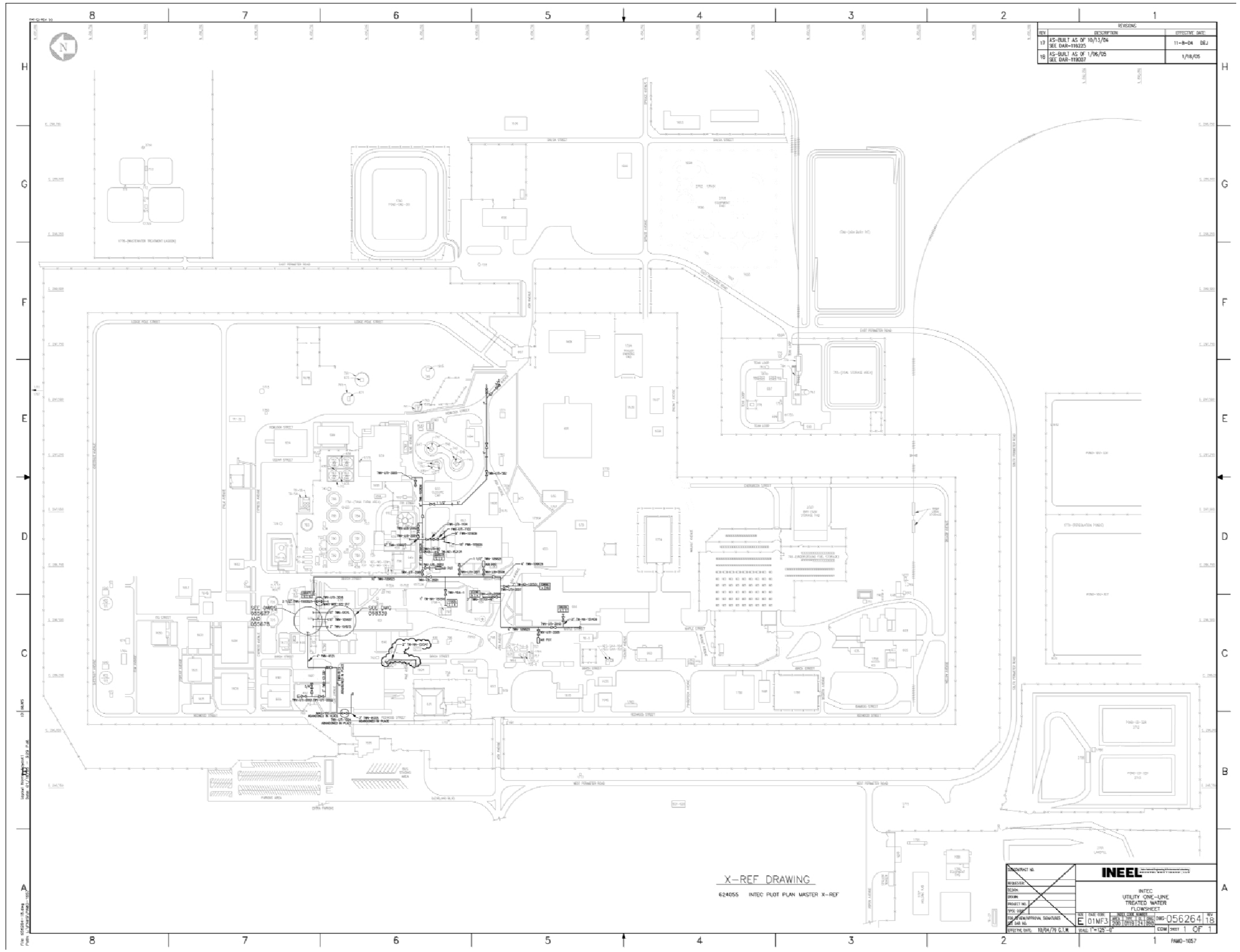

Figure K-8. Flowsheet for the Idaho Nuclear Technology and Engineering Center utility one-line treated water.